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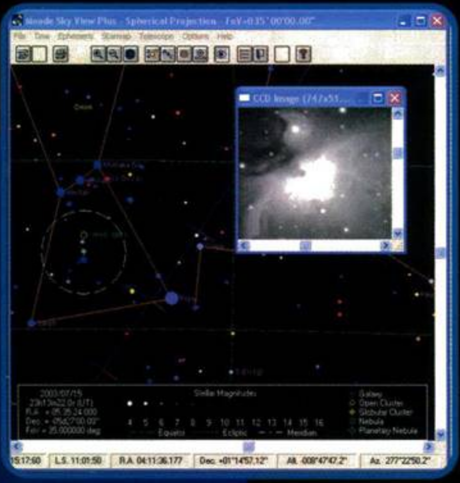

2003/07/15
Fov = 35.000000 deg

15:17:60 | LS 11:01:50 | RA 04:11:36.177 | Dec +01°14'57.12" | Alt 008°47'47.2" | Az 277°22'50.2"

Planetarium program showing Orion region.

Image of Mars made with an LPI connected to a 12" LX200GPS, a composite of 36 images automatically selected and registered by the Autostar Suite software. Control of the telescope was via Autostar Suite remotely over a network connection.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

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Meade 14" LX200GPS-SMT Schmidt-Cassegrain, with standard-equipment Zero Image-Shift Microfocuser, Primary Mirror Lock, and Autostar II Controller; shown with optional 14" Superwedge.

(below, right to left) 8" LX90; 8", 10", and 12" LX200GPS-SMT Schmidt-Cassegrains.

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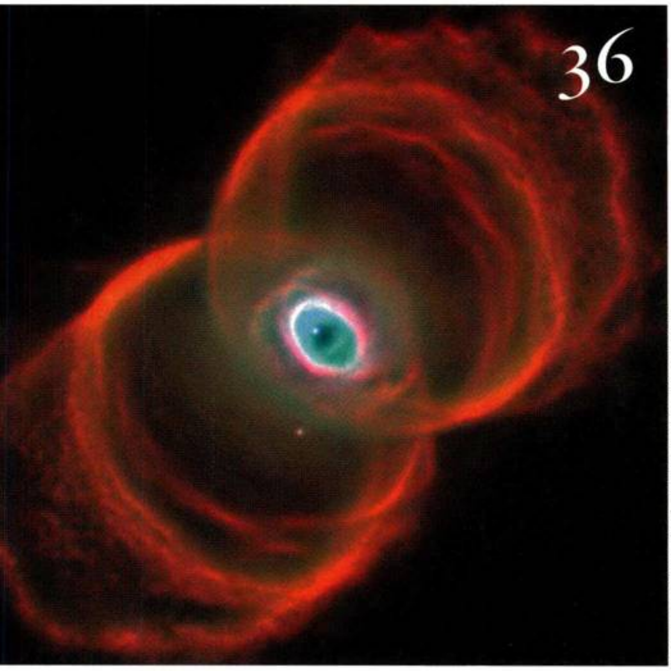

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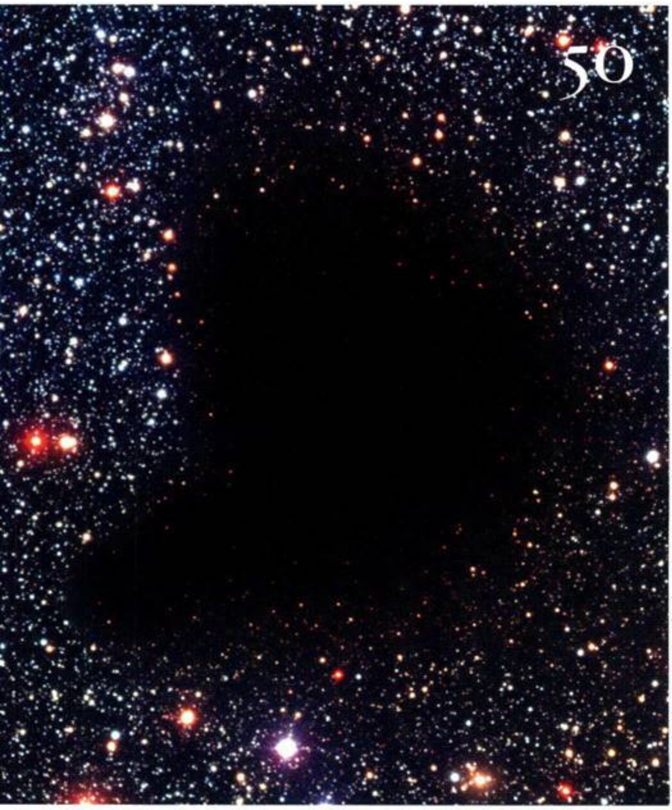

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With nearly 130,000 images to its credit, the Hubble Space Telescope's Wide Field and Planetary Camera 2 has opened our eyes to the universe. RICHARD TALCOTT

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Neutrinos have been called the tiniest bits of reality ever imagined by human beings — but astronomers are discovering they're essential for understanding how the universe works. ALISON BOYLE AND KEN GRIMES

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50 The black cloud

A cold, dark mass of gas and dust lurks nearby, blocking all light behind it. Find out what this pulsating blob may be spawning within. KEN CROSWELL

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Working before telescopes were invented, Tycho Brahe made thousands of meticulous observations that helped transform astronomy into the hard science it is today. DAN FALK

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80 Octans, Chamaeleon, and Volans

At first glance, the southerly estates of the Octant, Chameleon, and Flying Fish may not appear to possess many riches, but observers who look closely at these humble constellations will find plenty deep-sky rewards. TOM POLAKIS

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84 The lure of meteorites

Bits of rock and metal — some large, some small — fall to Earth every day. Some of this material is collected and offered for sale. Want to own a "piece of the sky"? Will that be cash, check, or charge? RAYMOND SHUBINSKI

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Build your own astronomical library with tips from a collector who's amassed several thousand titles. MICHAEL E. BAKICH

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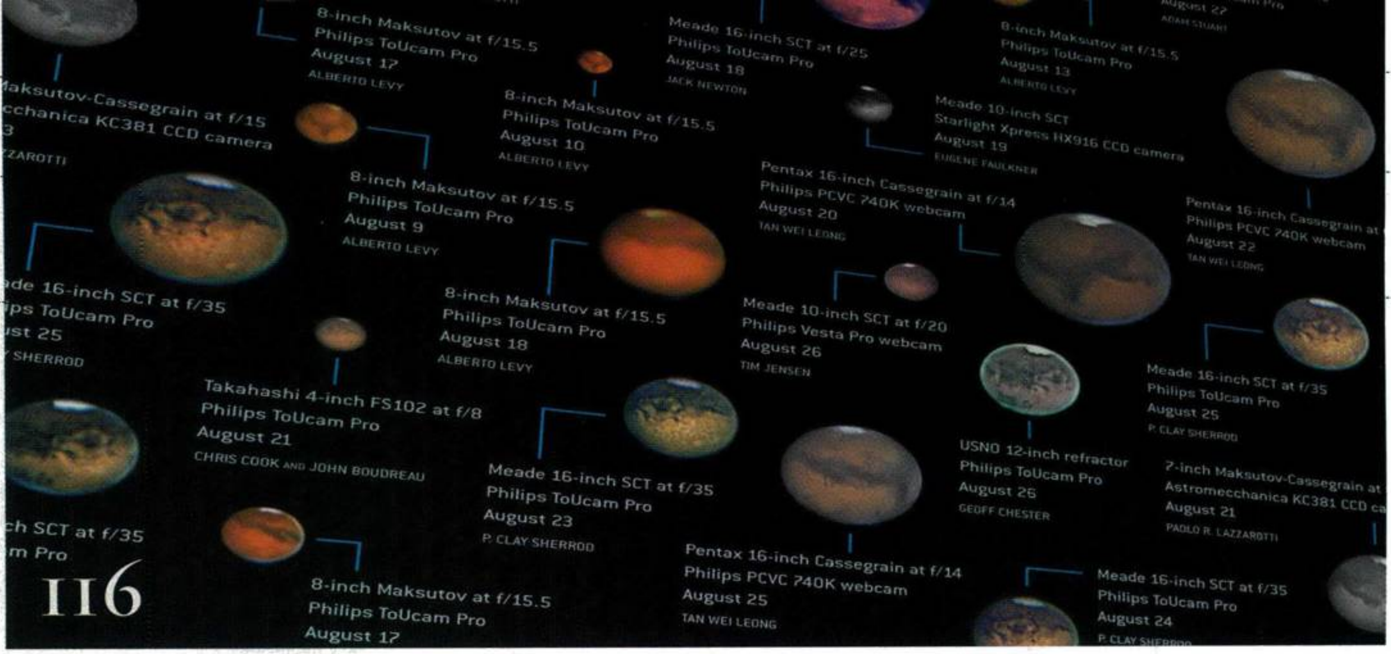
Many of today's webcams produce quality images of bright objects such as the Moon or planets but flunk the long-exposure test. Learn how to modify webcams and successfully capture images of dim, deep-sky objects. KEITH WILEY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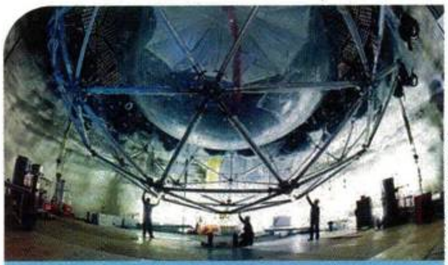
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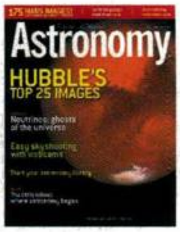

Astronomy
HUBBLE'S
TOP 25 IMAGES

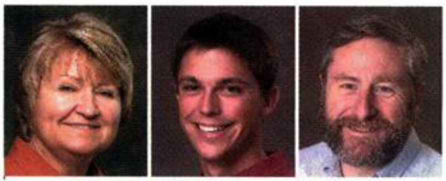
ON THE COVER

This past August, Mars made its closest passage to Earth in nearly 60,000 years. On August 27, 2003, with Mars at opposition, the Hubble Space Telescope imaged the Red Planet, creating the best Mars shot ever taken from Earth orbit. HST/STScI

BY DAVID J. EICHER

New and old faces at *Astronomy*

Please join me in welcoming Valerie Penton, the newest addition to *Astronomy*'s editorial staff. Valerie joins us as editorial assistant; her background is in office administration, and she has held various positions with companies in the Milwaukee area. A Milwaukee native, Valerie now resides in Pewaukee, Wisconsin, with her husband Dean, three cats, and a golden retriever named Mandy. Valerie volunteers at the Milwaukee Humane Society, and she often visits nursing homes with her cat to entertain patients. She also enjoys reading mysteries, quilting, and doing yoga. Valerie is eagerly looking forward to learning a great deal about astronomy as she helps to run the busy offices of this magazine.



THE LATEST ADDITIONS to *Astronomy*'s staff: Valerie Penton, Matt Quandt, and returnee Robert Burnham. *ASTRONOMY*: WILLIAM ZUBACK

I ask you to help me congratulate Matt Quandt, who was recently promoted to assistant editor. A graduate of Marquette University, Matt is a journalism expert whose enthusiasm for astronomy has blossomed over the past few months. Before he began as intern at *Astronomy*, Matt worked on marketing and public relations for Summerfest, Milwaukee's lakeside music festival, and a Christmas tree farm. He also pours energy into cheering for the Wisconsin Badger football team and the Marquette basketball team.

Last but hardly least, help me welcome back Robert Burnham, who rejoins *Astronomy* as a senior editor. Longtime readers know Robert's important history with the magazine, ranging from associate editor through editor; Robert most recently served as a contributing editor. Now Robert is back full-time, and he will be a mainline force in the magazine's future. An amateur since the mid-1950s, Robert is most interested in observing the Moon and planets and following advances in solar system astronomy and cosmology.

Robert has written a number of astronomy books, including *Great Comets* (Cambridge University Press, 2000) and *Reader's Digest Children's Atlas of the Universe* (Reader's Digest Books, 2000). His latest book is *Exploring the Starry Sky* (Cambridge University Press, 2003). Currently, Robert is working on a detailed handbook for backyard telescopic exploration of the Moon.

Robert lives in Hales Corners, Wisconsin, with his wife Pat. Aside from writing, Robert enjoys reading, hiking, and birding. Welcome back, Robert! And congratulations to Matt and Valerie.

As always, I invite you to contact me with comments about the magazine. E-mail me at editor@astronomy.com. I will always be listening.

Yours truly,

Dave Eicher
Editor

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VoL. 31 No. 12

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Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope	**$595**
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Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

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ETX-70AT Astro Telescope	**299**

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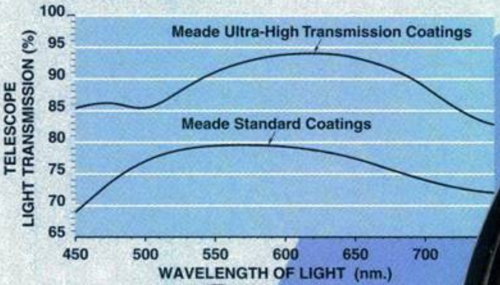

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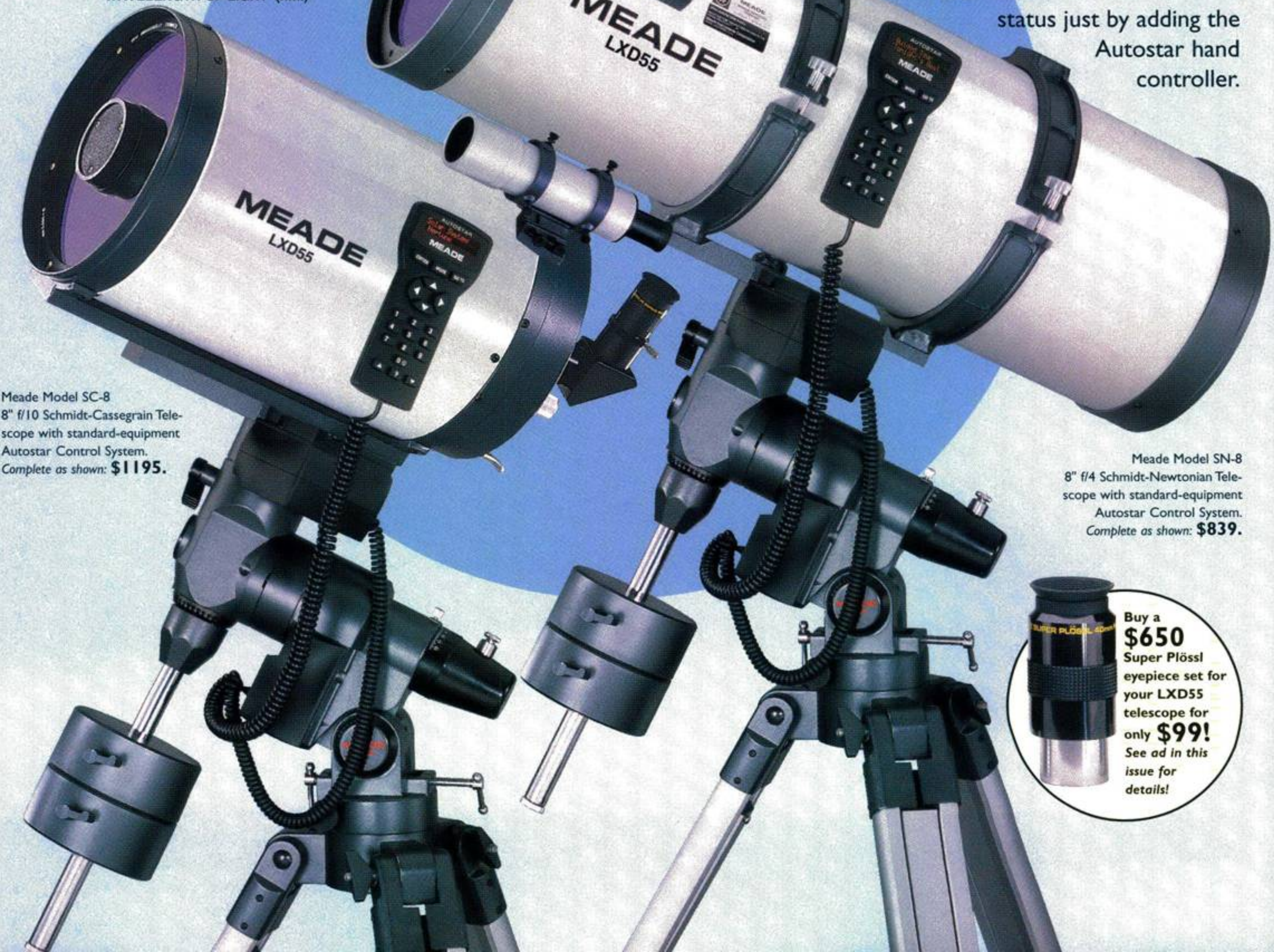

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8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
Complete as shown: **$1195.**

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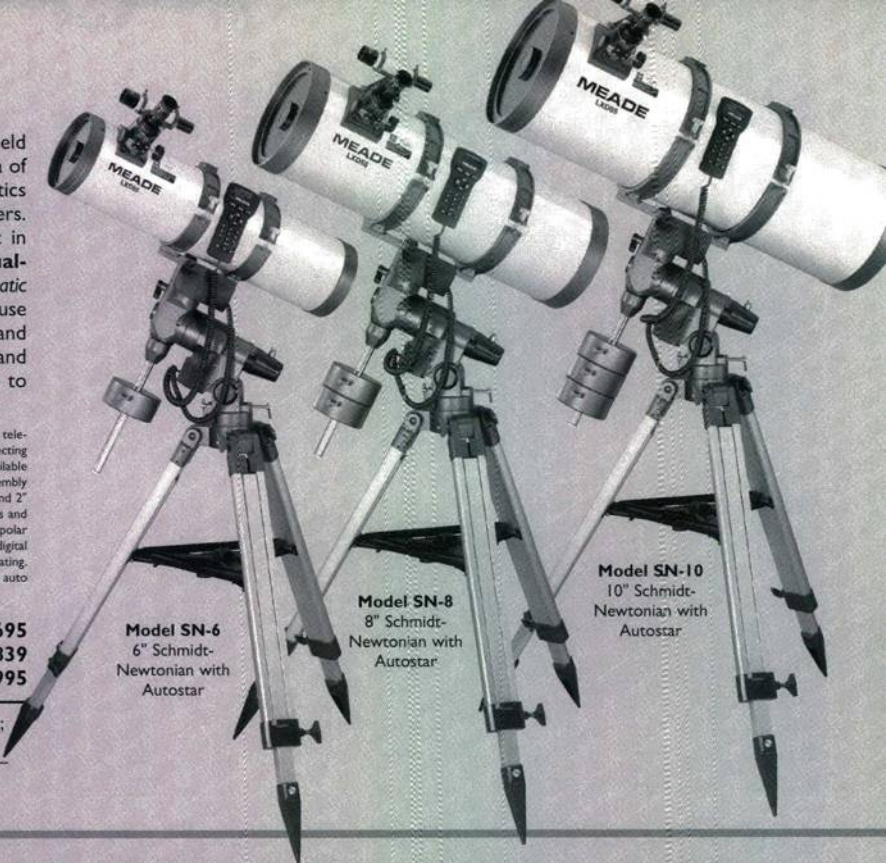
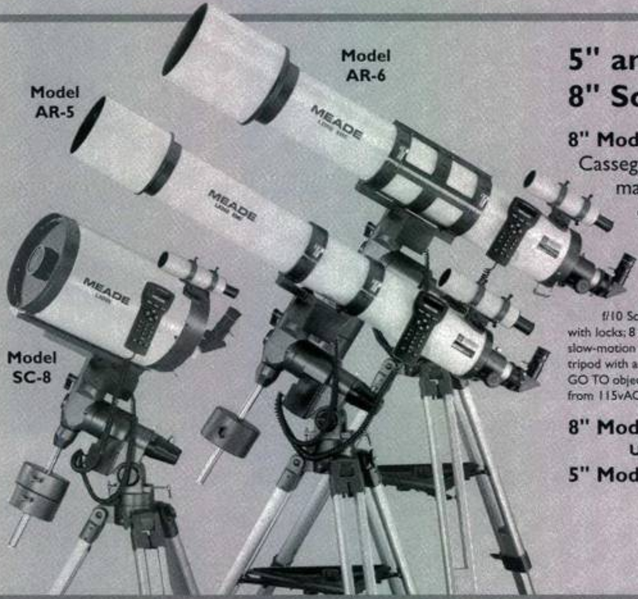
SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.


MEADE
Model SN-6
6" Schmidt-Newtonian with Autostar
Model SN-8
8" Schmidt-Newtonian with Autostar
Model SN-10
10" Schmidt-Newtonian with Autostar



5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

SPECIFICATIONS: Models SC-8 Schmidt-Cassegrain and AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 8" f/10 Schmidt-Cassegrain with MgF_2/standard coatings or 5" f/9 or 6" f/8 achromatic refractor with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm viewfinder; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9 speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

8" Model SC-8 Schmidt-Cassegrain . . $1195

UHTC group for Model SC-8 — $175

5" Model AR-5 Achromatic Refractor . . 695

6" Model AR-6 Achromatic Refractor . . 895

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; 4.5°/second for rapid-slew of the telescope across the sky; plus automatic sidereal-rate RA tracking. ***#497 Autostar Controller may be added at any time in the future and permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2003

MEADE
Model SN-6EC
6" Schmidt-Newtonian with Electronic Controller
Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller
Model AR-5EC
5" Achromatic Refractor with Electronic Controller

MEADE®

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal. **Super Plössls** (SP; 4-elements; 1.25"; 52°): **6.4, 9.7, 12.4, 15, 20, 26mm** each: **$79.95** (4.54); **32mm** (52°); **40mm** (44°) each: **99.95** (5.26); **56mm** (52°; 2") **199.95** (7.02)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

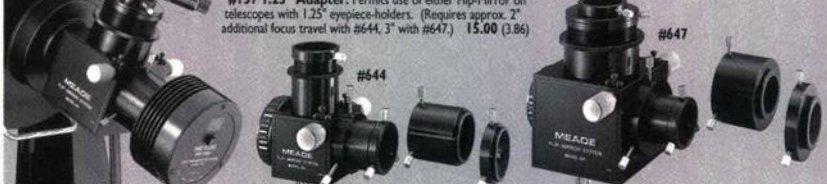
CCD-Photo-Visual Flip-Mirror Systems

Use with *any* brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)



#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g. LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries. **$249.95** (9.85)

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

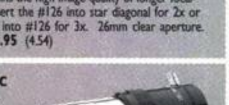
Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

Series 4000™ 2x Apochromatic Barlow Lens



#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included. $99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

#911B
#908B
#911X
#908X

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes; 36mm dia. **149.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-35mm camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; 1.25": $29.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron Schmidt-Cassegrain. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your 35mm camera.

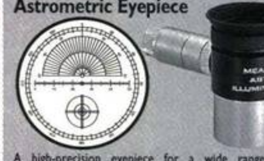
$39.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

MA12mm Illuminated Reticle Astrometric Eyepiece

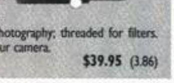


A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

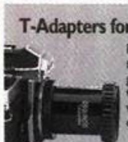
Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography with 35mm cameras; permits easy selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for Schmidt-Cassegrains



Rigidly couples 35mm camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

RIVERS CAMERA, Dover, NH.
Orders & Information: 800-245-7963.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

WOODLAND HILLS CAMERA & TELESCOPE, Woodland Hills, CA. Orders: 888-427-8766; Info.: 818-347-2270.

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KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

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The Meade 30th anniversary sale

Buy a Meade telescope and receive a $650 Meade Super Plössl eyepiece set for only $99!

Now for a limited time, to celebrate Meade Instruments' 30 years in telescopes, you can buy a Meade telescope* and receive a full set of Meade premium-grade Super Plössl eyepieces for only $99 additional. Never before have we made such an incredible offer available for such a wide range of our most popular telescope models.

Choose from more than a dozen qualifying Meade telescopes *(see listing at right)*, mail us your check for $99, and we'll ship your Super Plössl eyepiece set directly to you. And we'll pack your eyepieces in the Meade #771 foam-lined aluminum carrying case, itself a $49.95 value if purchased separately. For complete details see the HOW TO ORDER box at right.

Designed and manufactured to exacting standards, Meade Series 4000 Super Plössl eyepieces deliver wide 52° apparent fields (44° for the SP40mm) with all of the resolution, edge-of-field sharpness, and color correction demanded in the most advanced visual applications. All eyepieces are brand-new and factory fresh; each is multi-coated, includes a soft rubber eyeguard, and is individually packed in a thread-on poly container. There are no finer general-purpose eyepieces available.

The Meade #771 aluminum carrying case, included with this special offer, provides rugged, secure storage for your Super Plössl eyepiece set.

This special offer includes the following eyepieces:

SP6.4mm	$79.95
SP9.7mm	79.95
SP12.4mm	79.95
SP15mm	79.95
SP20mm	79.95
SP26mm	(standard equipment)**
SP32mm	99.95
SP40mm	99.95
#771 Aluminum Carrying Case	49.95
Total price if purchased separately:	**$649.60**

***Telescopes qualifying for this special offer include:**

ETX (EC or AT) models: ETX-90, ETX-105, ETX-125

LXD55 models: 6" SN-6, 8" SN-8, 10" SN-10, 8" SC-8, 5" AR-5, 6" AR-6, 6" SN-6EC, 8" SN-8EC, 5" AR-5EC

LX90, LX200GPS models: 8" LX90; 7", 8", 10", 12", 14", 16" LX200GPS

HOW TO ORDER

1. Buy any qualifying Meade telescope from an authorized Meade dealer in the U.S.A.

2. Fax or mail a copy of your dealer's invoice, plus the completed warranty card packed with the telescope, along with your payment of $99 to Meade Instruments/Attn: Customer Service, and request the "$99 Eyepiece Offer." *Requests must include your complete shipping address and phone number.*

3. We will ship your eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed.

Other terms and conditions: Payment may be made by personal check (payable to Meade Instruments) or credit card (VISA or MasterCard). **California residents must add $7.67 sales tax, for a total payment of $106.67.** This special offer is valid only for new Meade telescopes ordered and received within the U.S.A. after 8/15/02 and is subject to change without notice. (Outside the U.S.A. contact your Meade international distributor.) There is no limit to the quantity of telescopes each person may order: each qualifying telescope is eligible to receive the special eyepiece package. Prices shown are suggested U.S. mail-order retail prices. **The SP26mm eyepiece (shown in photos above) is packed with each qualifying telescope as standard equipment.

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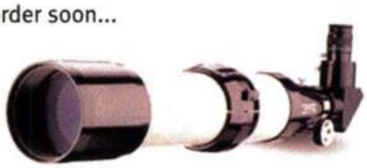

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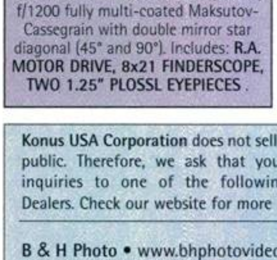

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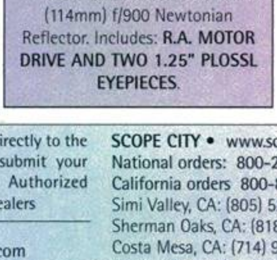

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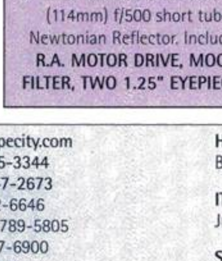

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Astronomy's anniversary

Congratulations on 30 years of excellent publications. At the end of every month, I begin to salivate for the newest issue of *Astronomy*. ☾ This has been true since I made the transition seven years ago from being a music specialist to a generalist teaching grades six and seven.

THE BIG DIPPER, whose seven stars form the body and tail of Ursa Major the Great Bear, is a familiar sight in the night sky to many people. PAOLO CANDY

My "Big Crunch" came when I realized that, despite a rich art training, I was unprepared to teach science. I owe your staff and writers a huge "thank you" for getting me through a steep learning curve.

Because astronomy integrates all the sciences, I have sought answers to an array of questions. Condescension is never lurking when your writers break down a complex concept, and their analogies and metaphors are clear enough that anyone can relate to them. I truly appreciate this.

— **JOHN PALMER,** VANCOUVER, B.C., CANADA

Please accept my sincere congratulations on the superb 30th anniversary issue of *Astronomy*. Steve Walther definitely would have approved of your tribute to his wonderful brainchild.

I worked closely with Steve during the early days of the magazine, and I was present the night he collapsed in 1977 at a swank, lakeside thank-you party for all the magazine's contributors (whom he had flown in and put up at his own expense).

I'm also sure he'd be pleased the magazine is in capable hands — those of people who love the stars as much as he did.

— **JIM MULLANEY,** EXTON, PENNSYLVANIA

Observing basics

"Beginner's luck" by Glenn Chaple (September 2003) was a great article. I'm an avid astronomer, and I haven't been able to give up my binoculars.

I'm still in awe of the night sky, as if I see it for the first time every night. I look for a new constellation each year and then watch as it floats across the sky. The steady star patterns like the Big Dipper and Cassiopeia are my favorites.

— **CATHY VECCHIO,** EAST MEADOW, NEW YORK

Just the facts

In last month's "Letters", reader Dean Mitchel questioned if the recordings I said were made in the minutes after the Challenger exploded in 1986 really existed ("Trial by fire," July 2003). Then, he disturbingly suggested I made it all up to embellish the article. That's when the "What? Is this guy serious?" light went off in my cerebral control panel.

I was referring not to the telemetry, which stopped the moment the craft exploded, but to *internal* astronaut-to-astronaut conversations during the long minutes before the still-intact crew compartment plummeted into the sea. While NASA denies any post-explosion tapes exist, the astronauts, in fact, were alive and fitted with voice recorders.

The lawsuit filed by *The New York Times* sought the actual audio tapes of internal conversations, whatever they may have contained. *The Times* argued the tapes are public records, like airliner cockpit voice recordings. NASA, already having released a transcript to the public, refused, citing the emotional inflection of the words and wishing to preserve family privacy. In the end, the case went to the Supreme Court, which ruled narrowly in NASA's favor.

While I certainly make my share of mistakes, I will never fabricate anything, unless I receive a serious bribe to do so.

— **BOB BERMAN,** CONTRIBUTING EDITOR

Correction

The panoramic picture of Yosemite National Park's Glacier Point featured in "Astronomy in paradise" (September 2003) was created by Morris Jones.

— ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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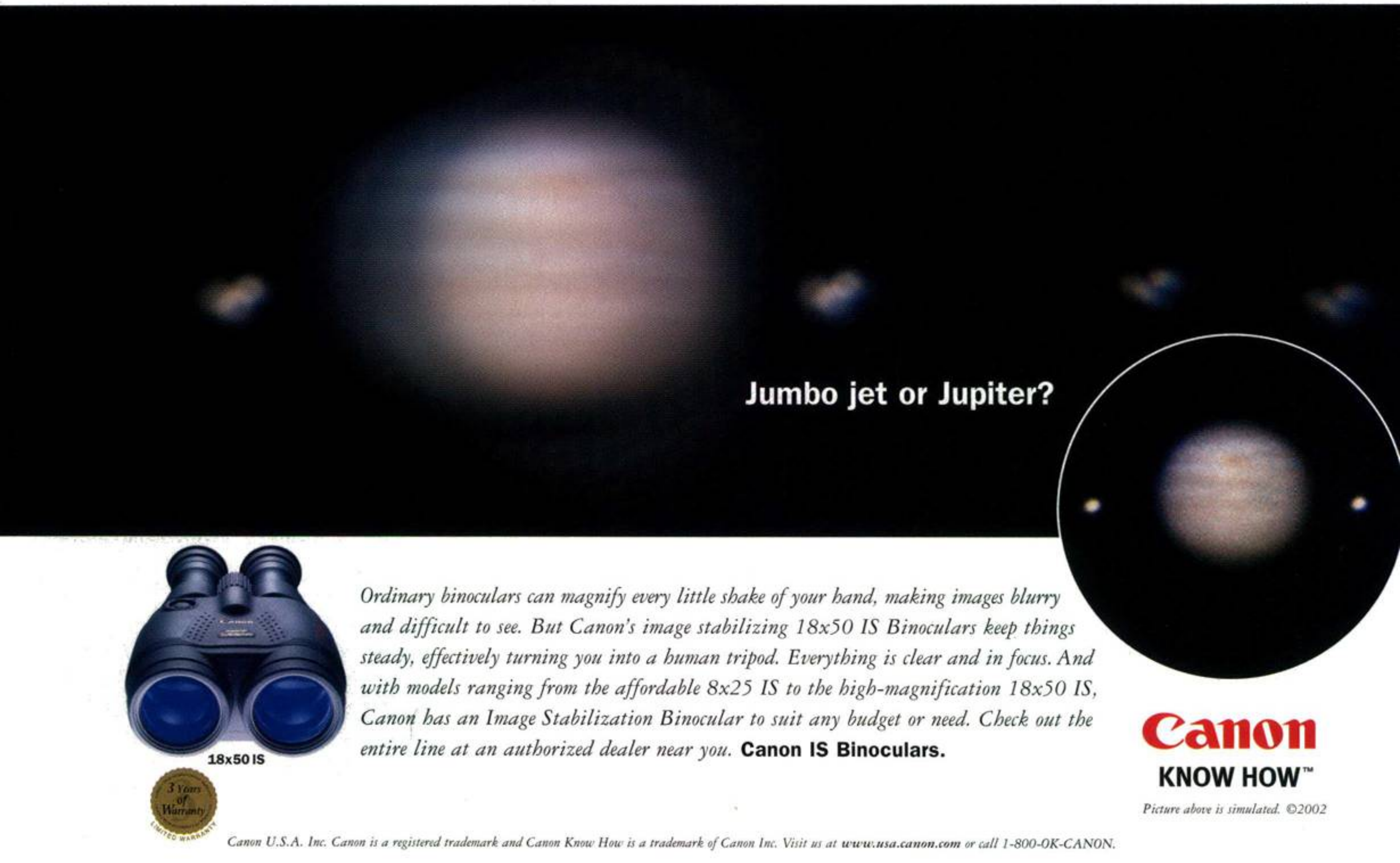

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BY BOB BERMAN

No time to lose?

Astronomers are punctual people.

We have to be. A botanist can study a rose at nine or noon, a surgeon can remove your troublesome cerebral cortex at any hour. We, alas, can miss a total eclipse or occultation if we're just a minute late. Our clock-drives whirringly remind us of time's relentless progression as they keep our telescopes aligned against Earth's tireless turning. But consider this: Perhaps time itself does not exist at all.

Since my "time" article in February 2000, the temporal tempest has scarcely abated. Indeed, time always has been a bothersome affair for physicists and philosophers alike. The present is self-evident, but does the "past" exist outside of a concept in the human mind? We can picture an event or remember a conversation. But that recollection is itself a neuro-electrical impulse occurring in the brain in the present moment. The future is also just a concept. Is there really a past or a future outside of thoughts that are themselves confined to the "now"?

Science has had its own reasons for doubting time. Newton's laws, Einstein's relativity, Quantum equations — all are time symmetrical; their laws operate just as well backward as forward. A movie showing the interactions of subatomic particles makes just as much sense when viewed in reverse. The whirling of clocks or planets does not validate time. Simultaneous events are not the same thing as time. Earth may fly around the sun 84 times while Uranus orbits once, but what does that prove?

Making things worse, the rate at which events pass changes depending on the object's speed and the local gravitational field. A traveler can perceive a single second while her stay-at-home cousin *simultaneously* experiences fifty years. How can anything so fickle be a fundamental reality? By contrast, the universe's unequivocal constants, like the speed of light in a vacuum, never vary regardless of circumstance.

To make sense of it all, Einstein conceived of space-time, which expresses motion so it remains logical and non-contradictory. It still doesn't change the fact that passage *through* space and time vary in wonderful and wacky ways. Here's how space-time works:

If you sit on a chair, you do not travel through any space (relative to the room around you) but you still pass through time. You age and experience one day every 24 hours. If you start to walk, you traverse spatial dimensions while also continuing your motion through time, which now unfolds at a slightly slower rate. At the speed of light, you move through lots of space but completely stop traveling through time. Time does not pass at all.

With space-time, the more you zoom through one component, the less you move through the other. Light passes only through space, not time. If you aim a flashlight toward the sky, then each photon has already reached the farthest edges of the universe. The photons arrived there in *no* time. They don't traverse time at all.

The recent book *The End of Time: The Next Revolution in Physics* by British physicist Julian Barbour takes potshots at time on every page: "It is change that we perceive as occurring all around us, not time. In fact, time doesn't exist."

Barbour imagines taking a snapshot of the universe at one moment. "If you put such snapshots together," he explains, "we perceive the passage of time. But of course, the action produced by running pictures together [like frames in a movie] is an illusion."

Time must have a direction of flow in order to make sense, and physicists have long believed that the second law of thermodynamics (entropy) supplies this "arrow." After all, the act of going from order to disorder, like your underwear drawer, is always a one-way affair. In closed systems (like the Sun and Earth taken together) things, overall, get steadily more disorganized. But some physicists insist that order is just a human concept. Disorder, they say, is the more likely way for random events to unfold. No law at all, and no necessity or role for time.

A recent, even wilder time concept involves black holes, where, some theorists believe, space and time actually switch roles. Space would become time and vice versa. Once inside a black hole's event horizon, you would *have* to keep moving forward, just as you're compelled to keep trudging ahead in time here on Earth.

Others argue that this makes no sense, because coming to a stop at the singularity in the black hole's center would amount to your time coming to a halt — and what could that mean?

A confusing, ambiguous, unanswerable mess? Maybe.

In 1998, however, experiments at CERN — the European Organization for Nuclear Research — in Geneva, Switzerland, and confirmed at Fermilab in Batavia, Illinois, showed that kaons (subatomic particles consisting of two quarks) changed into antikaons at a slower rate than the supposedly time-symmetrical matching process where antikaons turn into kaons. This surprising discovery was the first piece of evidence supporting the directionality of time.

So time might just be real after all. And that's good enough to make me feel better about wishing you a Happy New Year. ◼

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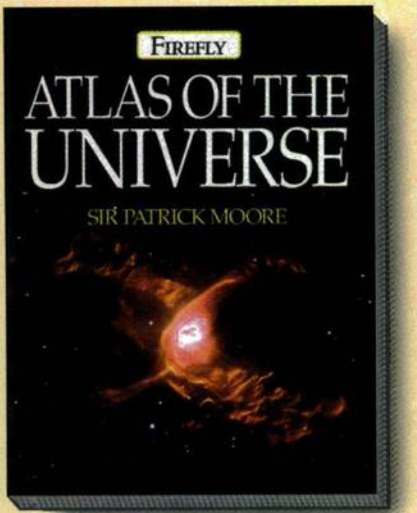
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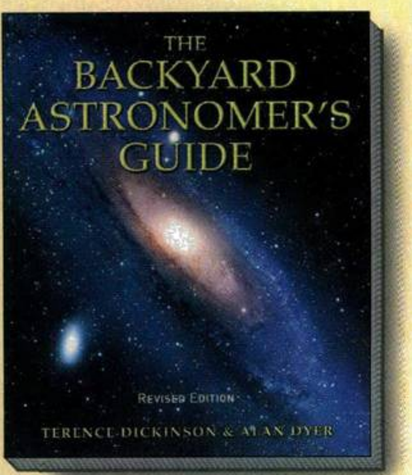
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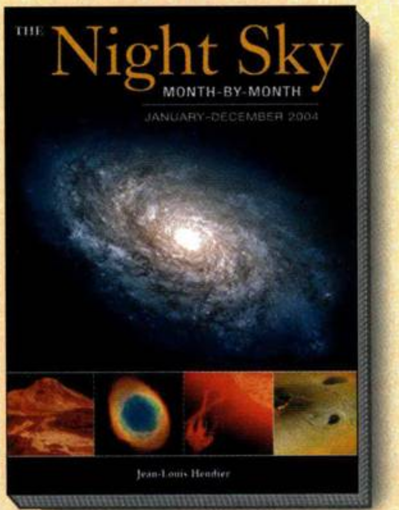
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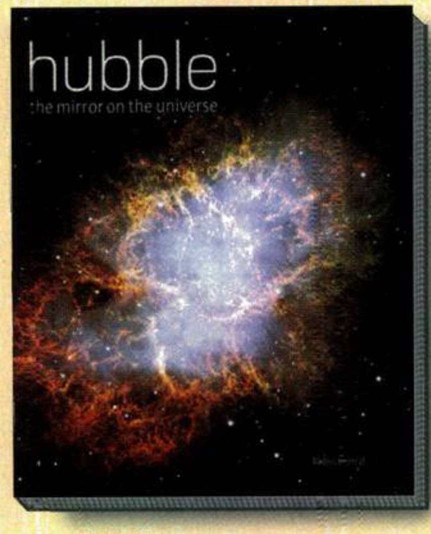
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BY GLENN CHAPLE

Binocular benefits

Ladies and gentlemen, welcome to our forum on binoculars for astronomy. I'll begin by responding to an e-mail sent by John Guarino of Rio Rancho, New Mexico. John asks, **"Which is better for the beginning observer — binoculars or a telescope?"**

Most veteran amateur astronomers would agree that it's wiser to purchase astronomically sound binoculars before investing in a telescope. Having said that, I realize most budding astronomers will ignore this advice and go for the telescope. As a youth smitten with astronomy, I opted for a telescope instead of binoculars. After I began using my telescope, I realized many sights are better suited for a binoculars's wide field of view. Binoculars nicely bridge the gap between naked-eye and telescope observing. You owe it to yourself to purchase good binoculars. I'll now entertain questions from the floor. Yes, the gentleman in the back:

"What should I spend on binoculars?"

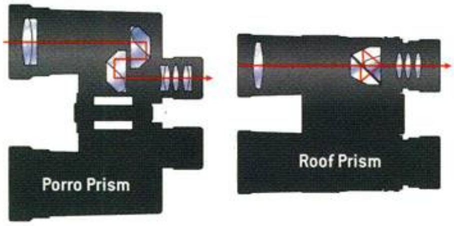
You can buy functional binoculars for less than $50. For top quality, expect to shell out $100, $200, or more. As the saying goes, you get what you pay for. Next question — the lady in the third row:

"Where can I get binoculars?"

A good place to start is a camera shop where high-quality optical goods are sold. Also, check out the product reviews and ads in *Astronomy* if you decide to order by mail or on-line. A gentleman near the back has a question. Go ahead, sir:

"Is there a design and size binoculars that's best for observing?"

Great question! Binoculars come in two main optical designs — roof prism and porro prism. The porro prism design allows more light to reach your eyes and is preferred for astronomical use. As for size, you can't go wrong with 7x50s. The "7x" refers to the magnifying power, and the "50" is the diameter in millimeters of each objective lens (the lenses in front). 7x50s pack enough magnifying power and collect enough light to capture many sky objects, yet they're light enough to handle with comfort. I see your hand is still up. Did I miss the boat with my answer?



THE PORRO PRISM DESIGN (left) allows more light to reach your eyes, so is thus preferred for astronomical use. The roof prism design (right), however, is more compact. ROEN KELLY

"No, I just want to know if there are any other features I should look for."

Lots! The method of focus is important. Most binoculars feature a center focus: Turn a knob and both barrels focus simultaneously. Because many of us have different vision in each eye, it's critical that your binoculars feature a *diopter* control that allows you to focus the right eye lens separately. Also, consider the type of glass used in the prisms — BaK4 (barium crown) is preferred — and the extent to which the optics are coated to prevent internal glare. The lady on the left:

"Is there anything in tonight's sky that I can look at with binoculars?"

Definitely! The all-sky map on page 63 will help you locate the following objects:

The *Seven Sisters*, or *Pleiades*, is the perfect binocular sky object. With binoculars, you can enjoy a stunning view.

The *Double Cluster in Perseus* is best observed on a clear, moonless night. With the unaided eye, you should see a misty patch of light. Your binoculars will split this patch into two and may show you some individual stars.

The *Orion Nebula* lies below Orion's belt in a vertical row of faint stars that make up his sword. Binoculars reveal something odd about one of the "stars" in the sword — it looks like a tiny glowing cloud. This is the great Orion Nebula. I'll feature this cosmic showpiece in February.

The *Andromeda Galaxy* can be seen as an oval smudge of light — you'll see the bright nucleus of this galaxy located 2.7 million light-years away.

We have time for one last question. The woman in the front row:

"Have you told us everything we need to know about binoculars?"

Hardly! If you want more information about binoculars, check out Phil Harrington's article "Everything you need to know about binoculars" in the June 2001 issue of *Astronomy*. You can also access this article by logging onto Astronomy.com. Phil also wrote an excellent book, *Touring the Universe with Binoculars*, which, together with 7x50 binoculars, makes a perfect holiday gift for any astronomer.

I'd like to suggest a special observing project for all of us. The annual Ursid meteor shower reaches peak activity on the evening of December 22/23. These meteors receive little attention because the shower isn't as rich as the more celebrated Geminids, which peak the evening of December 14. I've never seen the Ursid meteors, so let's make plans to take a break from the holiday madness to check out this shower. We can expect to see about a dozen Ursids per hour radiating from an area near the "bowl" of the Little Dipper.

Next month, we'll take a look at *two* January planets. Clear skies, and thanks for being a great audience.

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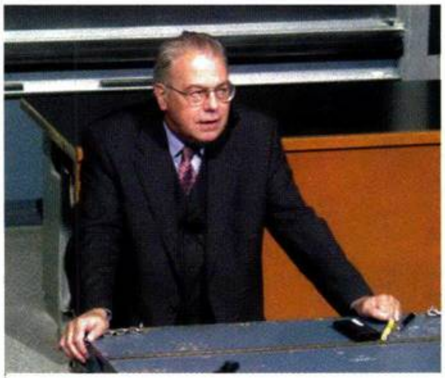
BY WILLIAM SCHOMAKER

David Morrison

Like better-known superheroes everywhere, saving Earth from devastation isn't David Morrison's full-time job: He's a senior scientist at NASA's Astrobiology Institute in Mountain View, California. And when he's not checking the universe for a pulse, he's dead serious about keeping watch for falling sky.

With hundreds of asteroids and comets traversing the solar system, Morrison is one of a handful of scientists toiling to inventory the swarm of potential rocks of doom that could render human civilization an ashy footnote in the fossil record.

In 1992, he chaired a NASA congressional advisory panel that initiated the Spaceguard Survey Project to protect our planet from Armageddon. Asteroid 2410 Morrison is named in his honor.



DAVID MORRISON remains vigilant for rogue space objects threatening dire encounters with Earth. ASTRONOMICAL SOCIETY OF THE PACIFIC

How real is the threat of a cosmic collision with Earth?

The impact threat is very real but also fairly small — the probabilities are at the level where some people worry a lot while others dismiss the risk as of little interest. One can engage in endless arguments as long as we discuss impacts only in terms of probabilities or statistics. But this really isn't a game of chance at all. There either is or is not a comet or asteroid that will hit Earth in our lifetime. If there is, we need to find it and take action to defend our planet.

What's the worst-case scenario for an asteroid or comet impact?

The dinosaurs experienced the worst case — a mass extinction that eliminated most species on Earth and redirected the course of biological evolution. Fortunately, today there aren't any asteroids in Earth-crossing orbits that are nearly as large as the "dinosaur killer" (10 miles across). The largest undiscovered Earth-crossing asteroid is probably about two miles in diameter, which is large enough to mess up the planet's environment for a couple of years by lofting dust into the stratosphere. The sunlight would be dimmed and crops would fail. This is the type of threat we are most concerned about today.

With so much at stake, how are we mitigating this threat of global devastation?

A couple dozen professional astronomers are involved with searches, and they are doing more than just "eyeing the skies." The telescopes of the Spaceguard Survey are sophisticated, automated systems that can pick out a tiny, faint asteroid moving against a background of millions of stars. The current Spaceguard objective is to discover 90 percent of the near-Earth-asteroids (NEAs) larger than 1 km in diameter by the end of 2008.

Other telescopes, including some operated by very skillful amateur astronomers, will make follow-up observations and calculate the objects' orbits.

These are real searches for real objects. We know enough about the statistics of impacts. Our job today is to find the asteroids one at a time and calculate their orbits to determine if any pose a threat of collision. So far, more than two thousand NEAs have been discovered, and none of these will hit Earth within the next century. Perhaps there is no NEA that is on a collision course, but we won't know until we find and track all of them.

What have recent "close calls" taught us, if anything?

Widely publicized close calls have taught us that the Spaceguard system is working! Asteroids have been passing close to Earth for centuries, but only recently have our surveys become good enough that we are beginning to find them, even some very small ones.

Can we really go out and deflect or destroy an asteroid with our name on it?

If there is an asteroid on a collision course, the Spaceguard Survey (or its successor) should provide us with a warning several decades in advance. Given this much time and the motivation to protect our planet, I am confident that the spacefaring nations would find a way to deflect it. Several ideas ought to work because only a very small push would be required if it were applied many years before the collision. But no defense concept has been designed or tested yet, and a wide range of opinion exists about whether we should invest in such technology in the absence of a specific, identified threat. In the end, however, these decisions will be made by political leaders, not scientists.

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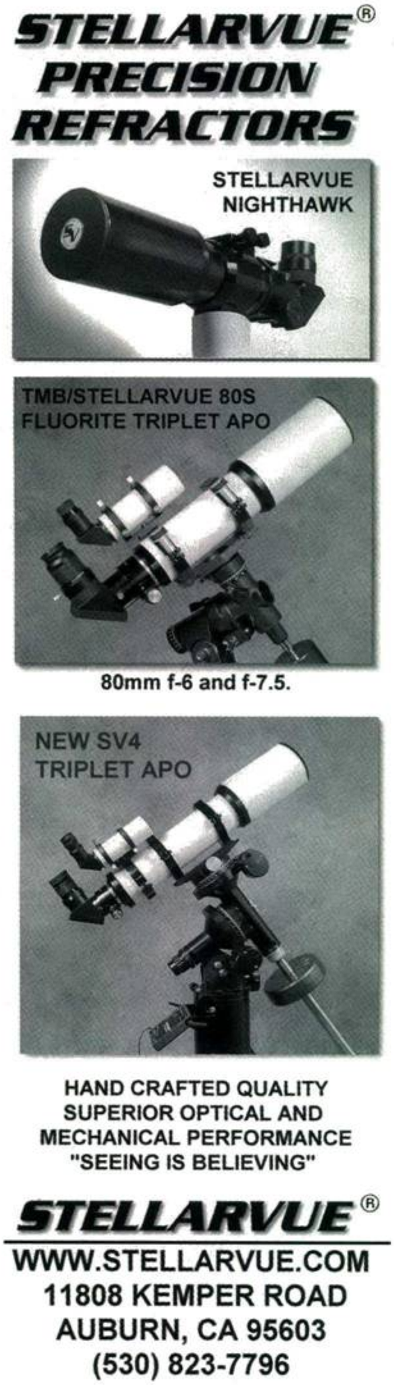
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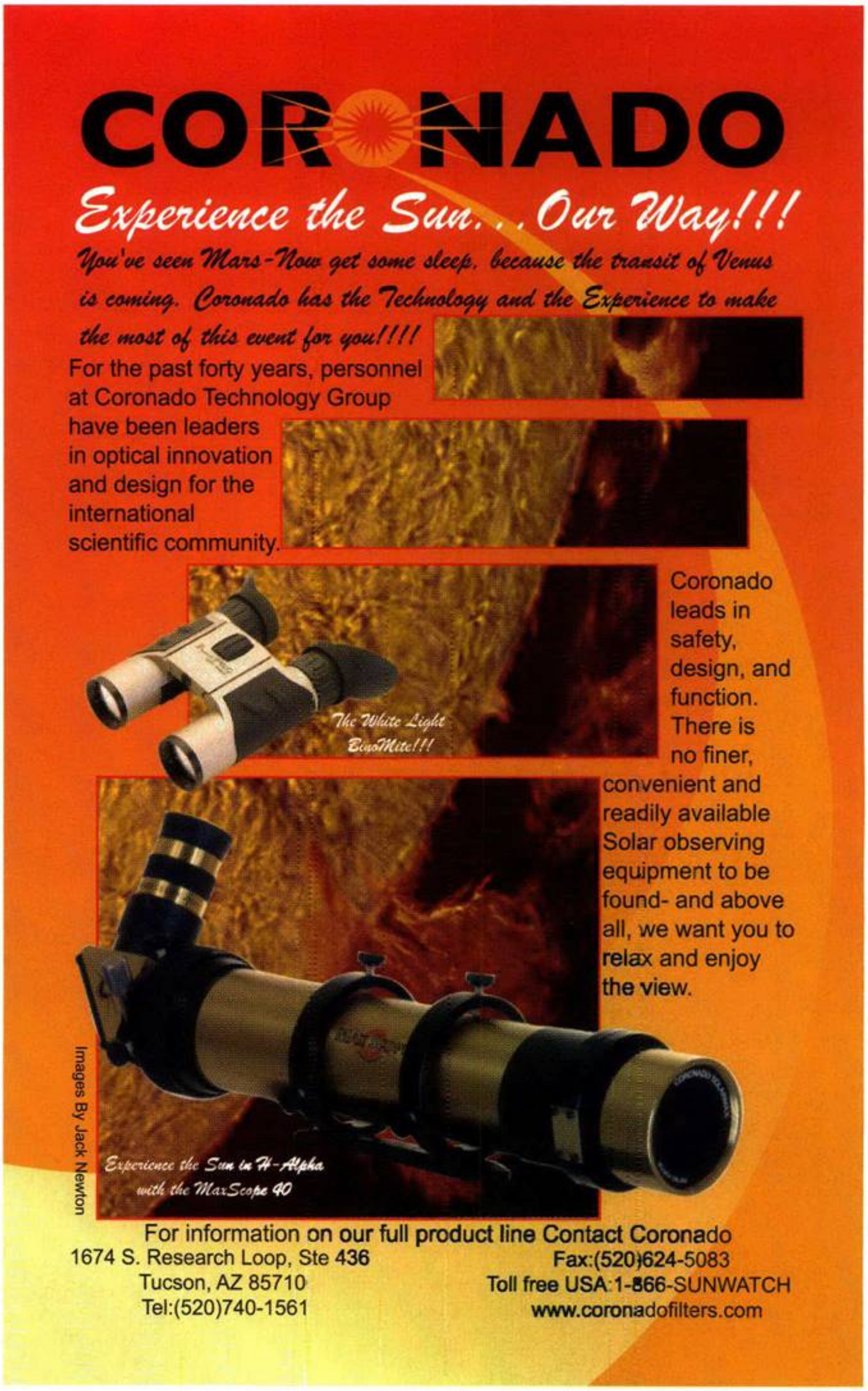
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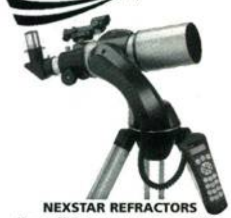

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C6-R 6" Refractor	799.00
C6-N 6" Newtonian Reflector	399.00
C8-N 8" Newtonian Reflector	649.00
C10-N 10" Newtonian Reflector	849.00
C9¼-S 9.25" Schmidt Caessegrain	1399.00

ADVANCED COMPUTERIZED

C6-R-GT 6" Refractor	999.00
C8-N-GT 8" Newtonian Reflector	949.00
C10-N-GT 10" Newtonian Reflector	1149.00
C8-S-GT 8" Schmidt Caessegrain	1299.00
C9¼-S-GT 9¼" Schmidt Caessegrain	1699.00

NEXSTAR REFRACTORS

Nexstar 60-GT	209.95
Nexstar 80-GT	299.95
Nexstar 60/80 Soft Case	39.00
Nexstar 80/114 Hard Case (for Scope only)	64.95

NEW NEXSTAR REFLECTOR

New Nexstar 130mm	Call

FIRSTSCOPE SERIES

Firstscope 114 EQ	189.95
Firstscope 114 EQ Short	139.95

CELESTRON REDUCER/CORRECTOR F/6.3 114.95

POWER TANK 12V RECHARGEABLE POWER SUPPLY.

- 7-AMP Hour w/2 12 output cigarette lighter ports and 3v/6v/9v outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power Halogen emergency spotlight

$59.95

CELESTRON TELESCOPE ACCESSORIES

AC Adapter f/Nexstars	19.95
Car Battery Adapter f/Nexstars	19.95
2X Barlow 1.25" Short Tube	29.95
Counterweight Bar Assembly 8"	84.95
Case for C8/C5	171.95
Piggyback Mount 8"	33.95

MOTORS

Dual Axis Drive for CG-4	99.95
Single Axis Motor for CG-5	59.95
Dual Axis Drive for CG-5	99.95

CELESTRON FILTERS

Contrast-Booster Filter - 1-1/4"	34.95
LPR A	59.95
LPR B	84.95
Polarizer Set 1¼"	39.95
Sky Filter #2	39.95
4 piece 1.25" Filter Set	34.95

DIAGONALS

Diagonal Erect 1¼" 45°	34.95
Hybryd Diagonal .96" 1¼" 45°	34.95
Diagonal Erect 1¼" 90°	34.95
Star Diagonal 1¼" 90°	33.95
2" Mirror Star Diagonal	74.95
Stereo Binocluar Viewer	489.95

ULTIMA EYEPIECES

5mm, 1¼"	69.95	7.5, 1¼"	69.95
10mm	69.95	12.5mm, 1¼"	69.95
18mm 1¼"	69.95	30mm, 1¼"	84.95
42m, 1¼"	89.95	35m 1¼"	96.95
2X Ultima Barlow Lens	62.95		

E-LUX SERIES 2" EYEPIECES

26mm	46.95	32mm	51.95
40mm	64.95		

OMNI SERIES 1.25" EYEPIECES

4,6,9,12.5,15,20,25mm	34.95
32, 40mm	43.95

X-CEL SERIES 1.25" EYEPIECES

2.3mm, 5mm, 8mm, 10mm, 12.5mm, 18mm, 21mm, 25mm	55.95

AXIOM EYEPIECES

15mm 1¼"	129.95
19mm 1¼"	139.95
23mm 1¼"	139.95
19mm 2"	169.95
34mm 2"	209.95
40mm 2"	249.95
50mm 2"	274.95

JMI ACCESSORIES FOR NEXSTAR 5

Carry Case	139.95
Celestron Case	149.95

FINDERSCOPES

9x50 Finderscope Kit	69.95
7x50 Polaris Finder Scope with Illuminator & Bracket	159.95
Quick Release f/7x50 find	42.95
Star Pointer Finderscope	21.95
Polar Axis Finder f/CG-4/5	39.95

GUIDING SYSTEM

Radial Guider	79.95
Micro Guide Eyepiece	134.95
10mm Plossl Reticle	84.95
Standard Illuminator	39.95

MOUNTS

New Upgraded CG-5 Mount	349.95
CG-5 Computerized mount	659.95
Vibration Suppression Pads	39.95

NIGHT VISION ASTROLIGHTS

Night Vision LED Light	16.95

T-ADAPTER/TELE EXTENDERS

Tele Extender Deluxe	48.95
T-Adapt. f/Schmidt Cassegrains	24.95
Universal 1¼" T-Adapter	24.95
T-C 16mm Adapter	26.95

ASTRONOMY SOFTWARE

THE SKY for Windows

Sky Level 2 or 3	Call
Sky GSC (CD ROM) Level 4	Call

REDSHIFT

Redshift 3	9.95
Redshift 5	9.95

STARRY NIGHT SOFTWARE CALL

Tele Vue®

REFRACTOR TELESCOPES

102 f/8.6 APO Doublet Complete Kit #WXC-4086	2635.00
102i Short Tube 4" F/8.6 Kit #WBC-4086	3580.00
Renaissance-102 - Solid brass, 4", f/8.6, APO #BXC-4086	3175.00
NP101 4" 4-element, 540mm, f/5.4 #NPC-4054	3595.00
85mm Air Spaced Doublet APO 600mm f/7 Green Tube Kit #GXC-3370	2080.00
85mm Ivory Tube Air Spaced Doublet APO 600mm f/7Kit #WXC-3370	2080.00
76mm APO Doublet 480mm, f/6.3 Green Tube Kit #GXC-3063	1675.00
76mm APO Doublet 480mm, f/6.3 Ivory Tube Kit #WXC-3063	1675.00
Pronto 70mm f/6.8 Green Tube Kit #GXC-2868	1120.00
Pronto 70mm f/6.8 Ivory Tube Kit #WXC-2868	1120.00
Ranger 70mm f/6.8 Green Tube Kit #RGD-2868	760.00

TELESCOPE MOUNTS

Tele-Pod Mount with Head	365.00	Ashwood Panoramic Mount	495.00
Walnut Panoramic Mount	605.00	Ashwood Gibraltar Mount	595.00
Walnut Gibraltar Mount	690.00		
Original Style Walnut Gibraltar Mount with SkyTour System	749.95		

Plossl Eyepieces

55mm 2"	228	40mm, 32mm 1.25"	110.00
25mm, 20mm 1.25"	95.00	15mm, 11mm, 8mm 1.25"	82.00

Radian 1.25" Eyepieces

18mm, 14mm, 12mm, 10mm, 8mm, 6mm, 5mm, 4mm, 3mm	240.00

PANOPTIC EYEPIECES

41mm 2"	495.00	35mm 2"	365.00
27mm 2"	330.00	24mm 1.25"	295.00
22mm 2"/1.25"	280.00	19mm 1.25"	240.00
15mm 1.25"	210.00		

NAGLER EYEPIECES

31mm 2"	620.00	26mm 2"	580.00
22mm 2"	460.00	20mm 2"	440.00
17mm 2"	385.00	16mm 1.25"	320.00
13mm 1.25	280.00	12mm 2"/1.25"	355.00
11mm 1.25"	280.00	9mm 1.25	280.00
7mm 1.25	190.00	7mm 1.25" Type 6	280.00
5mm 1.25"	280.00	4.8mm 1.25"	155.00
.5mm 1.25"	280.00	2.5mm 1.25"	280.00

ZOOM EYEPIECES

3mm-6mm Nagler Zoom 1.25"	380.00	8mm-24mm Click Stop Zoom	210.00

POWERMATES & BARLOWS

2x Powermate 2"	280.00	New 2.5x Powermate 1.25"	190.00
4x Powermate 2"	295.00	New 5x Powermate 1.25"	190.00
2x Barlow 1.25"	160.00	2X Big Barlow 2"	198.00
3x Barlow 1.25"	105.00		

DIAGONALS

2" Enhanced Diagonal	210.00	2" Everbrite Diagonal	275.00
1.25" Enhanced Diagonal	140.00	1.25" Everbrite Diagonal	190.00

ACCESSORIES

Starbeam	205.00	Bino-Vue	1030.00

WE STOCK THE COMPLETE LINE OF TELE VUE TELESCOPES EYEPIECES & ACCESSORIES

Vixen

80M refractor w/GP mount	1100.00
102M refractor w/GP mount	1100.00
ED80S refractor w/GP mount	1655.00
ED102S refractor w/GP mount	2200.00
ED102SS refractr w/GP mount	2400.00
FL102S refractor w/GP mount	2900.00
DED108SS refractor w/GP mount	4400.00
ED114SS refractr w/GP-DX mount	3700.00
NA120S refractor w/GP mount	2375.00
ED130SS refractr w/GP-DX mount	5700.00
R130S newtonian w/GP mount	1225.00
R150S newtonian w/GP mount	1575.00
R200SS newtonian w/GP mount	1700.00
VC200L catadioptric w/GP mount	2200.00
VMC200L catadiopt. w/GP-DX mt.	2400.00

LANTHANUM EYEPIECES

2.5mm, 4mm, 5mm, 6mm, 7mm, 9mm, 10mm, 12mm, 15mm 1.25"	120.00
18mm, 20mm, 25mm, 40mm 1.25"	120.00
30mm 1.25"	180.00
50m 1.25"	150.00

WIDE ANGLE LANTHANUM EYEPIECES

3.5mm, 5mm, 17mm, 22mm 1.25"	235.00
8mm, 13mm 1.25"	230.00
42mm 1.25"	330.00
8-24mm LV zoom 1.25"	171.00

BARLOW LENSES

2X barlow lens 1.25" #3677	45.00
2X-DX barlow lens 1.25" #3674	100.00

GREAT POLARIS MOUNTS

Great polaris equatorial mount	600.00
G.P. equat. mount w/ash wood trpd	990.00
G.P. equat. mount w/al 150 tripod	800.00
Great polaris-dx equatorial mount	920.00

WILLIAM OPTICS™

Megrez 80mm with 1.25 prism	649.00
Megrez 80mm with high reflective 2 Inch diagonal	669.00
Megrez 80mm with 1.25" Prism, 2" Photo Adapter, 1.25" VR Filter	669.00
High Reflective Rate Star Diagonal for SCT	129.95
High Reflective Rate 2 Inch Star Diagonal	99.95
45 Degree 1.25 Inch Erecting Prism	99.00
45 degree Erecting Prism for SCT and Maksutov	199.95
2 Inch- Newtonian focuser with zero image shift	139.00
2 Inch SCT Rotateable Focuser with Zero Image Shift	149.00

BUSHNELL®

COMPACT 4.5" REFLECTOR

Features a unique cradle mount which is convenient to use and transport. A wide field of view makes it easy to locate objects and keep them in view

- Aperture: 4.5"
- Focal Length: 400mm
- Eyepieces: 1.25" 4mm (100X), and 25mm (16x)
- Focuser: Precision Rack & Pinion, Tripod adaptable, includes convenient shoulder strap

129.95

PENTAX

WE CARRY THE NEW PENTAX XO & XW SMC EYEPIECES

KONUS

Optical & Astronomy Systems

#1780 Konusmotor - 500mm Newtonian Telescope with 6V R.A.Motor Drive	159.00
#1784 Konusmotor 114mm Newtonian Telescope with 6V R.A. Motor Drive	219.00
#1783 Konusmotor 90mm Refractor Telescope with R.A. Motor Drive	269.00
#1790 Konusky 150mm Refractor Telescope with Dual Axis Motor Drive	779.00
#1795 Konus Motormax 90mm (3.5") Maksutov-Cassegrain Telescope with Double Mirror Star Diagonal (45° & 90°)	249.00
#1793 Konusky 200mm Newtonian Telescope with Dual Axis Motor Drive	529.00
#1796 Konus Motormax 130mm (5.1") Maksutov-Cassegrain Telescope with German Polar Mount & Dual Axis Drive	569.00
#1798 Konus Motormax 150HM 6" F/1800 Maksutov-Cassgrain Telescope	829.00

DIGITAL ASTRO PHOTOGRAPHY

DIGI T RING ADAPTERS

Fits onto most 1.25" eyepieces *(with Removable Eyeguards)* and allows you to attach it to a Digital Camera (Requires a Digital Camera Adapter to connect to your digital camera)

Digi-T Ring for 1.25" eyepieces	29.95
Digi-T Ring Large for 1.25" eyepieces	29.95
Adapta View Camera Adapter f/Tele-vue & Meade Large Eyepieces	39.95

DIGITAL CAMERA ADAPTERS

allows you to connect your camera direct to a telescope (requires a T-Adapter) Digital Camera Adapter TO FIT Cameras with 28/37/49/52/58/62mm filter threads	24.95

Uni-T Adapter

Universal Eyepiece to T-Adapter for Spotting Scopes	34.95

Uni-Adapt Universal

Eyepiece to T-Adapter. (fits eyepieces from just under .97" to 2 1/16 ")	164.95

NIGHT NAVIGATOR

THE ELECTRONIC STAR LOCATOR

LOCATES AND IDENTIFIES CONSTELLATIONS QUICKLY.

- Scientific patented computer tracking system to accurately locate and identify constellations, planets, and stars quickly and effortlessly.
- Innovative built-in digital electronic compass automatically plots your location.
- Motorized map delivery system for easy sky navigation.

79.95

WE SHIP PROMPTLY ALL TELESCOPES INCLUDE U.S.A. WARRANTY

No Surcharge for MasterCharge or Visa Purchases. Personal checks welcome, will ship without delay. Name must be imprinted on check, also include address, phone, and a copy of major credit card or driver's license for reference. Shipping, handling and insurance additional. 14 day money back guarantee less shipping, with packing and blank warranty card, except film and paper. We ship UPS. Some items special order. All orders are subject to acceptance and verification. Second hand dealer's license #802862. Pictures are for illustration purposes only and may not be exact. Wa are not authorized Meade dealers.

Prices effective till Nov. 10, 03 **Please address all inquiries and orders to ASTRO. DEPT. #55**

Your Credit Card Will Only Be Charged At Time Of Shipping For Items Actually Shipped

Anyone can sell you a telescope.

Last year was the biggest in our history. We shipped 19,336 orders from ***astronomics***. And our business was up another 24% in the first eight months of this year. Why? Because our satisfied customers tell their friends that we take the time to make sure that each customer gets the right telescope or accessory – one that does what he or she wants – at a price they can afford.

We take the time to listen to what you need. We answer your questions truthfully and take the time to explain your options. And we have the experience – a staff total of over 160 years of experience using and selling telescopes – to make sure you get the telescope and accessories that are right for your needs.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not a sideline. We're a family-owned family-run full-line telescope dealer – not a few toy telescopes stuck off in the corner of some no-help department store, camera store, or gift shop as an afterthought. And, unlike camera store clerks, we don't work on commission, so we don't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help you pick the scope that fits your needs . . . and your budget . . . from the hundreds of Celestron, Discovery, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, and Vixen scopes we stock. And with our large inventory, we can usually ship you the right scope right away.

astronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and accessories, and a good price. Call us toll free at (800) 422-7876 and find out for yourself.

We ship 8" Meade LX90 and 7" to 10" LX200 GPS-*SMT* go-to scopes from stock.

Meade 8" LX200 GPS SMT

$2195

Many dealers don't. They don't keep a full inventory of telescopes in stock. Instead, they ask Meade to ship the scope to you . . . but not until after the dealer first charges your credit card or waits for your check to clear. If Meade is out of stock on a popular model when you order, you're out of luck. The dealer has your money, but you don't have a scope until Meade once again is able to ship.

We won't treat you that way at ***astronomics***. We keep Meade scopes in stock so we can ship your scope to you right away. Whether you're looking for an 8" Meade LX90 starting at $1495, the very latest 10" Meade LX200 GPS with new SMT (Smart Mount Technology) starting at $2745, or any Meade in between – the chances are good we have it in stock for you.

Meade scope prices are about the same anywhere you call. So why order a Meade from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

The **Meade 8" LX90** lets you enjoy go-to astronomy for not a lot of money. Only $1495 gets you a full-featured telescope with everything you need to start observing. It has an adjustable height tripod, Autostar computer with 30,223 star and object memory, 26mm 1.25" Super Plössl eyepiece, and 8 x 50mm finderscope. Optional UHTC (Ultra High Transmission Coatings) are available to give you up to 20% brighter images for only $175 additional.

$1495

Meade 8" LX90

Meade LX200 GPS-SMT telescopes with unique Smart Mount Technology have all the luxury and convenience features you've dreamed about since you first started astronomy – plus you can get optional UHTC (Ultra High Transmission Coatings) for up to 20% higher light transmission so you can see 20% more of the Universe.

Meade's *fully automatic* GPS (Global Positioning System) alignment system, with its true north and true level sensors and automatic magnetic declination correction, takes the time and guesswork out of setting up your LX200 and aligning it on the heavens. You'll be observing in mere minutes.

Unique Smart Mount Technology can improve your scope's pointing accuracy as you observe. A standard Lunar and Planetary Imager will take color pictures for you.

The GPS Autostar computer hand control, with its built-in database of over 145,000 stars and objects, will find deep space and solar system objects for you *automatically.* You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them.

Unlike many dealers, we keep Meade LX90 and LX200GPS-SMT scopes in stock at ***astronomics***. The chances are good we have one ready to ship to you.

More than 1,000,000 people a year visit our website for reliable information, helpful features, and secure on-line shopping.

www.astronomics.com

> I just wanted to say thank you! My husband loves the telescope, and all the accessories. They arrived one day before his birthday and you did a great job packaging them. Thank you for your great prices, and very quick shipping that made this possible! I look forward to buying from your store again!
>
> **Customer Quote of the Month #141**

Want a TeleVue? We have it all in stock.

NP-101 **$3595**

TV-85 **$2080**

Whether it's a telescope, an eyepiece (like the new 2.5mm, 3.5mm, and 11mm Type 6 Naglers at $280 each), or a photographic or visual accessory, if it's from TeleVue, the chances are good we have it in stock. Whether you want a Gibraltar, Panoramic, or TelePod mount; a Nagler, Radian, Panoptic, or Plössl eyepiece; a Powermate or Barlow; a BinoVue; an Everbrite 99% reflectivity diagonal; a light pollution filter; and more – we have it all. Others may say they carry TeleVue, *but we actually keep TeleVue in stock*. Call us and see.

Here are some of the TeleVue refractors we carry in stock for immediate shipment.

Ranger, 2.7" f/6.8 semi-apo	\$760^{00}
Pronto, 2.7" f/6.8 semi-apo	1120^{00}
TV-76, 3" f/6.3 apo	1675^{00}
TV-85, 3.35" f/7 apo	2080^{00}
TV-102, 4" f/8.6 apo	2635^{00}
Renaissance 102, 4" f/8.6 brass apo	3175^{00}
NP-101, 4" f/5.4 apo	3595^{00}

All of the above scopes come without a mount, but include an eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a tube ring for mounting, and a carrying case. Basic optical tubes, without these accessories, are also available.

"Optics as good as I have seen . . . in any telescope . . . at any price."

TMB 105

A *Sky & Telescope* review said the **TMB** triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price."

The TMB ED apo refractors have optically exceptional air-spaced triplet optics and high precision mechanics (such as a 3" focuser).

You can have an absolutely premium TMB triplet apo optical tube a lot sooner than you might think. For details and pictures, visit our website to see the TMB apo refractors that are the talk of experienced astronomers everywhere. Here's a list of the sizes available.

TMB 80 80mm (3.1") f/6 or f/7	\$1990^{00}
TMB 105 105mm (4.1") f/6.2	3590^{00}
TMB 115 115mm (45") f/7	4390^{00}
TMB 130 130mm (5.1") f/6	5390^{00}
TMB 152 152mm (6") f/7.9	7590^{00}
TMB 175 175mm (7") f/8	12,990^{00}
TMB 203 203mm (8") f/9	24,990^{00}
TMB 229 229mm (9") f/8.95	24,990^{00}
TMB 254 254mm (10") f/9	39,990^{00}
TMB 12", 14" and 20"	**prices on request**

For the ultimate lunar and planetary viewing, add the unsurpassed TMB Super Monocentric eyepieces, at $200 each, to your observing kit.

Our free info pack helps you pick the right Celestron, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, or Vixen scope.

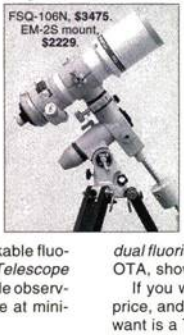
For the most detailed and fully illustrated information on the individual products we carry in stock, visit our **www.astronomics.com** web site. Or you can get our *free* information package AST by calling (800) 422-7876 or sending an e-mail to **questions@astronomics.com**.

Package AST includes our 8-page guide on how to pick the right telescope and our 16-page discount price list covering the 2000+ products we carry – from Antares, Astrozap, Canon, Celestron, Coronado, Discovery, Fujinon, JMI, Leica, Losmandy, Lumicon, Meade, Minox, Miyauchi, Nikon, Parallax, Pentax, Questar, Rigel Systems, SBIG, Sirius Optics, Software Bisque, Starbound, Starlight Instruments, Stellarvue, Swarovski, Swift, Takahashi, TeleVue, Thousand Oaks, TMB, Vernonscope, Vixen, Zeiss, and more. (Sorry, U. S. sales only.)

The information is yours for only the time it takes to make a free phone call. The information and pricing we send will make it the most useful minute you'll ever invest in astronomy.

Prices and specifications in this ad are current as of 9/10/03, but are subject to change.

Takahashi – *premium apochromatic optics on sale!*



FSQ-106N, $3475. EM-2S mount, $2229.

Ultra-premium optics that you can have *right now* . . . and on sale? Experienced astronomers know that's just what you get with the unsurpassed fluorite optics and fast delivery of the **Takahashi** *apochromatic* refractors we keep in stock.

The 3.1" **FS-78** fluorite doublet optical tube is on sale for **$1195!** Regularly $1379, you save $184!

Takahashi's unique 90mm f/5.6 **Sky 90 II** is on sale for **only $1849!** It's regularly $2279. You save $430! With dew shield retracted, this remarkable fluorite apo is less than 14" long! *Sky & Telescope* called it "an ideal travelscope for mobile observers, providing maximum performance at minimum size."

The best-selling 4" **FS-102** fluorite doublet optical tube is on sale for **only $1895**! Regularly $2349, you save $454!

The 5" **FS-128** fluorite doublet optical tube is **only $4495**! Regularly $5249, you save $754!

Finally, the big 6" **FS-152** fluorite doublet optical tube is on sale for **only $6995**! Regularly $9329, you save $2334!

We also stock the 22" long Takahashi **FSQ-106N** 4-element f/5 4" *dual fluorite* 4" focuser astrograph apo refractor OTA, shown on an optional mount to the left.

If you want a premium apo scope at a sale price, and you want it *right now*, the scope you want is a Takahashi from ***astronomics***.

Discovery Dobs are not cheap . . . just inexpensive.

8" f/6 DHQ

$449

Why settle for an imported Dobsonian with so-so mass-produced optics when premium made-in-the-USA quality costs no more? Discovery's optics are made to diffraction-limited standards by experienced optical craftsmen in California, one high quality mirror at a time. The 6" to 13.1" Discovery DHQ Dobsonians have a fast cool-down metal mirror cell, a thin vane diagonal spider, *two* 1.25" Plössl eyepieces, 2" metal rack and pinion focuser with 1.25" adapter, built-in tube balancing system, tube carry handle, oversized bearings, 6 x 30mm finder, and tube end dust cover.

Here are the prices for the fully-equipped Discovery DHQ Dobsonians. Freight from the factory in California is additional, as shown.

6" f/8 Discovery DHQ	**339^{00}**	+ $49 freight
8" f/6 or f/7 Discovery DHQ	**449^{00}**	+ $49 freight
10" f/4.5 Discovery DHQ	**649^{00}**	+ $69 freight
10" f/5.6 Discovery DHQ	**649^{00}**	+ $69 freight
13.1" f/4.5 Discovery DHQ	**999^{00}**	+ $185 freight

SBIG CCD cameras? We had 60 when this was written.

We had 60 SBIG CCD cameras in stock as this was written, at prices from $1995 to $6995. Why so many? Because we think it's important to keep products in stock so you can get what you want, when you want it, without having to wait for a dealer to order a product he doesn't stock. Is an inventory of 60 SBIG CCD cameras too big? We think our customers deserve nothing less.

astronomics

Our 25th year of friendly service, good advice, and money-saving prices.

680 SW 24th Avenue, Norman, OK 73069

Toll-Free Order Line: **(800) 422-7876** Catalogs/Questions/Advice: **(405) 364-0858**

We'll sell you the *right* telescope.

Stocking stuffers galore for the holiday season!

Ready or not, the holidays will soon be upon us. Here are a few of the many stocking stuffers that we keep on hand to brighten the day for any amateur astronomer.

Celestron rechargeable battery for only $\$59^{95}$!

Celestron's **Power Tank** 7 amp-hour 12V DC rechargeable battery will run your scope all night long. It has two cigarette lighter outputs; separate 3, 6, and 9V DC accessory outputs; emergency spotlight; recharger; shoulder strap;and more. It's only $\$59^{95}$. Why pay more for a battery that does less?

Observing books for half price!

When we bought 4000 deep space observing books at one time, we got them at some very special prices. We're passing our savings on to you, pricing them at 50% off retail. Just look at your savings . . .

Galaxies & The Universe 112 page soft cover helps you find hundreds of galaxies, reg. $19.95 .... $\$9^{95}$

Stars & Galaxies 200 page hard cover includes 344 of the best deep sky objects, reg. $29.95 .... $\$14^{95}$

Universe From Your Backyard helps you find 690 deep space objects, 188 page hard cover, reg. $29.95 .... $\$14^{95}$

CCD cameras starting at only $249!

SAC7B cooled 24-bit color

$499

SAC CCD cameras finally make serious CCD imaging possible at sensible prices. Even the owners of small scopes (such as the Meade ETX-90) can get into CCD imaging with a very affordable SAC camera.

Whether black and white imaging, single-pass full color imaging, tri-color imaging, or autoguiding – there's an inexpensive SAC CCD camera to do it. Full details are on our website at **www.astronomics.com**.

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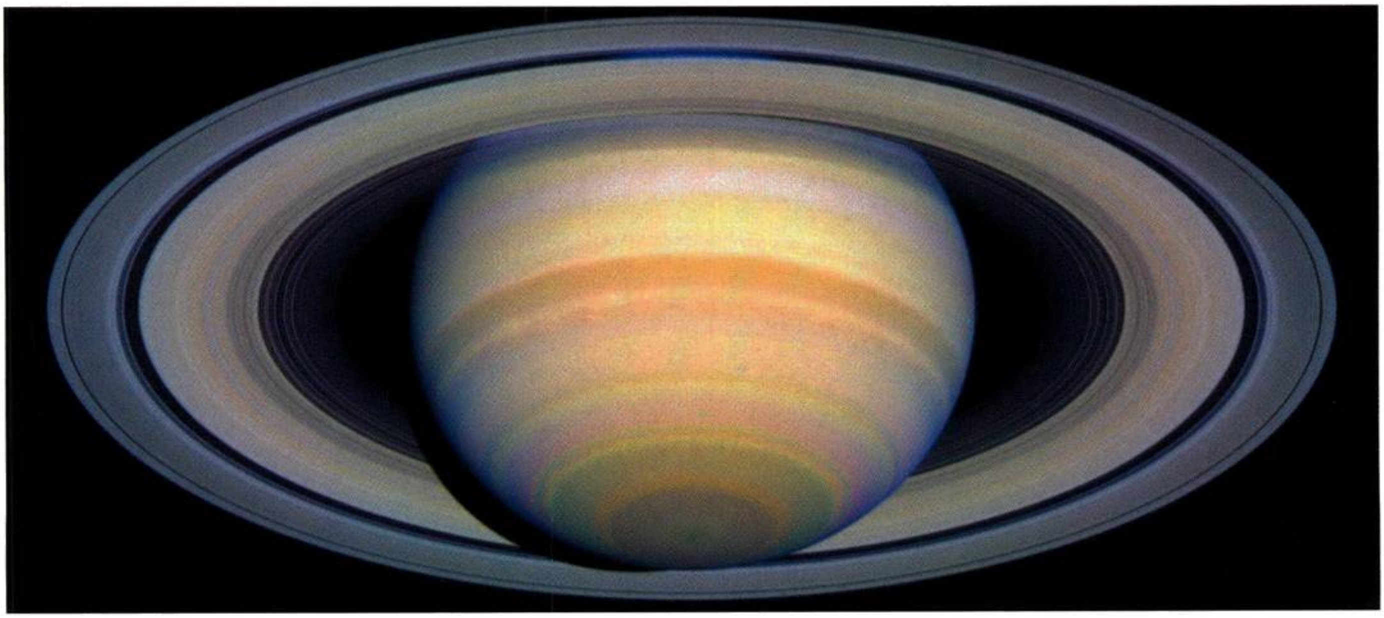
{ 12:03 } **HEATING BY SUNLIGHT MAY ALIGN THE SPIN AXES OF ASTEROIDS** smaller than 25 miles across, according to new research on the Koronis family of minor planets. Previously, scientists thought impacts would orient asteroid spins randomly.

news 12

Read all about it: Dirty domes on Europa, the Mars mission no one knows, the Galileo spacecraft dives into Jupiter, Halley's Comet photographed, and the gently rounded shape of asteroid Davida.



THE SHARP EYE OF HUBBLE took a spectacular series of Saturn images in March 2003. Saturn was then showing its southern hemisphere tilted toward Earth to the fullest extent. Note the rings' intricacies — unlike the three bland rings usually seen through backyard telescopes. NASA/E. KARKOSCHKA (UNIVERSITY OF ARIZONA)

PLANETARY ASTRONOMY

Hubble Space Telescope images Saturn

In the spring of this year, Saturn reached the point in its orbit where the planet's southern pole was tilted most fully toward the Sun. This gave astronomers — both professional and amateur — their best looks at the planet in years. Planetary scientists Eric Karkoschka and Martin Tomasko (University of Arizona) seized the opportunity, training the gaze of the Hubble Space Telescope on the ringed planet.

Shooting 36 images through 30 filters at wavelengths from the ultraviolet to the infrared, the scientists were looking to study Saturn's atmosphere. Specifically, they hope to study its structure and gaseous composition.

Saturn's axis tilts 27° to its orbit, giving it seasons resembling Earth's but much longer thanks to the planet's 29.5-year journey around the Sun. The last time its rings lay so fully open, in 1987, the northern side was on display.

Saturn's rings traditionally are divided into three broad rings: the outermost A ring, the wide B ring in the middle, and the gauzy C ring lying innermost. However, HST's spectacular view shows that such categories actually lump together hundreds, or even thousands, of rings.

Saturn-watchers eagerly await next July's arrival of the Cassini spacecraft, when it starts a multiyear tour of Saturn. — **ROBERT BURNHAM**

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32 **Fast and furious: powerful cosmic rays**

34 **Early Mars warm, wet — or cold and dry?**

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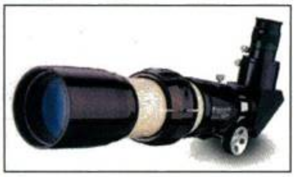

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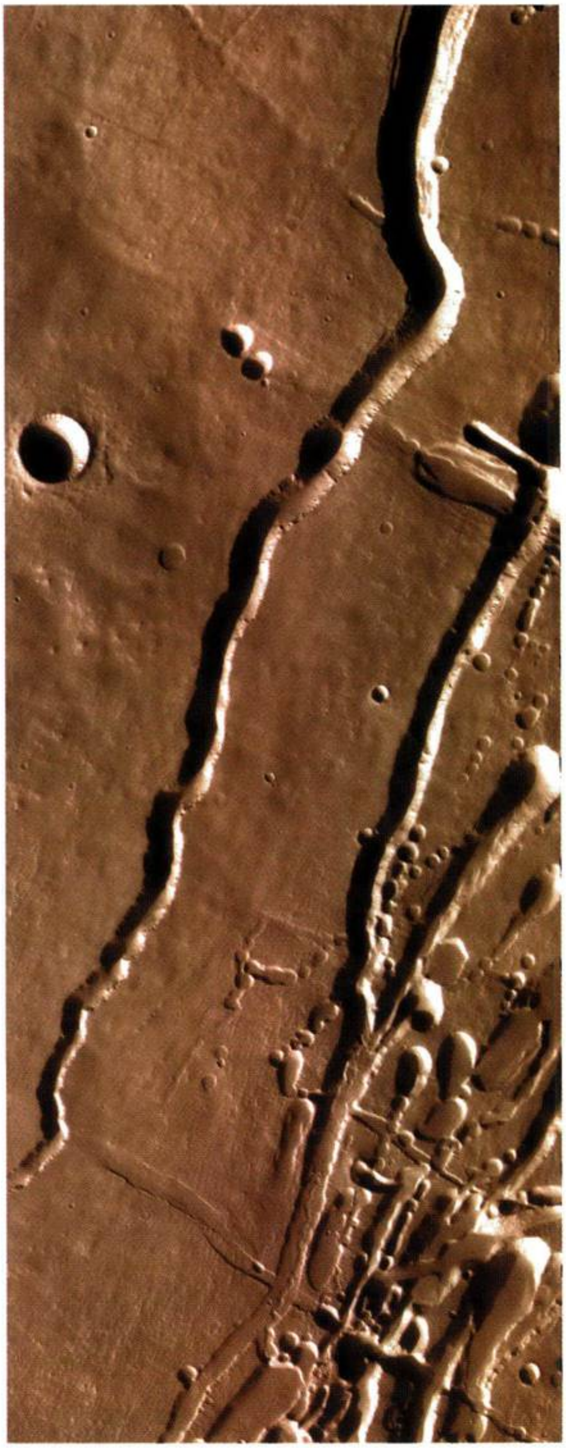
BIG FLARES ON STARS OTHER THAN THE SUN appear to be predictable, say astronomers who monitored radio emission from variable stars Beta Persei and V711 Tauri. Magnetic field activity in each star accurately foretold radio-flare activity.

MARTIAN GALLERY

Volcano's labyrinth

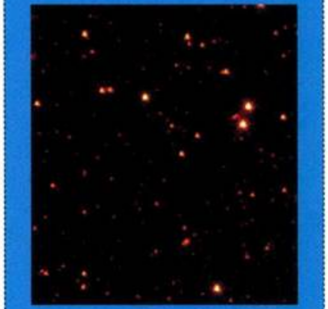


CHANNELS, GROOVES, AND PITS scar the southern flank of the giant martian volcano, Pavonis Mons, as seen by the THEMIS imager on Mars Odyssey. Channels began as covered lava tubes that opened up as their roofs collapsed. Faulting produced the shallower, straight troughs. NASA/JPL/ASU/IMAGE 20030821A

INFRARED ASTRONOMY

SIRTF launched

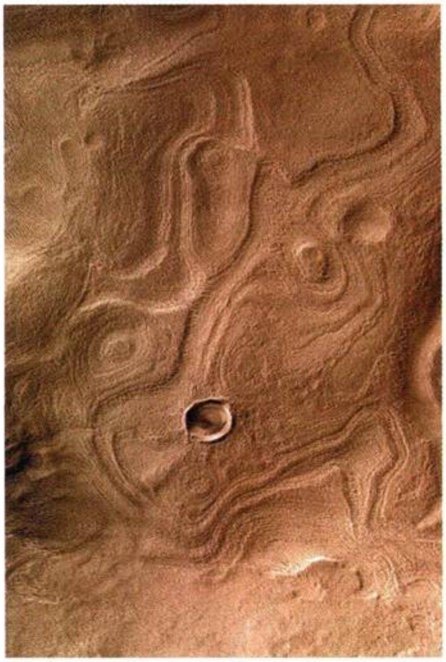
Launched August 25, 2003, NASA's Space Infrared Telescope Facility, or SIRTF, has begun returning its first data and images.



SIRTF'S FIRST-LIGHT image captured a field of stars and galaxies in Perseus. NASA/CALTECH

"These first images have exceeded our expectations," reports SIRTF scientist Michael Werner. "We can't wait to see the images and spectra we'll get once the telescope is cooled down and instruments are working at full capacity." — VANESSA THOMAS

MARS PHOTOJOURNAL



SWIRLING LAYERS OF ROCK wind across part of easternmost Hellas Planitia on Mars. This site lies between the Dao and Harmakis valleys. Scientists think the bands trace sedimentary deposits covered by a younger mantling layer. This mantle is now eroding, giving the layers a pitted appearance. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE E22-00427

ASTROBIOLOGY

Dirt makes ice mounds on Europa

Jupiter's moon Europa has a skin of ice perhaps 13 miles (20 km) thick. It covers a global ocean of brine that may be 60 miles (100 km) deep. The moon's icy surface displays many geological features, including domes.

DIRTY ICE may be the key to building domes on Europa. NASA/JPL

These are hills of ice up to 4 miles (6 km) across and 300 feet (100 meters) high. In the past, planetary scientists thought warm ice had sufficient buoyant force to raise the domes by itself.

However, researchers Robert Pappalardo and Amy Barr (University of Colorado) have found that making a dome also demands chemical impurities, such as salt or sulfuric acid, mixed into the ice. The source of such impurities would be Europa's global ocean.

"We're excited," says Pappalardo. "We now think it's possible that any past or present life in the ocean, or just the chemicals from it, may be lifted right to the surface.

"Essentially, it would be like an elevator ride for microbes." — **R. B.**

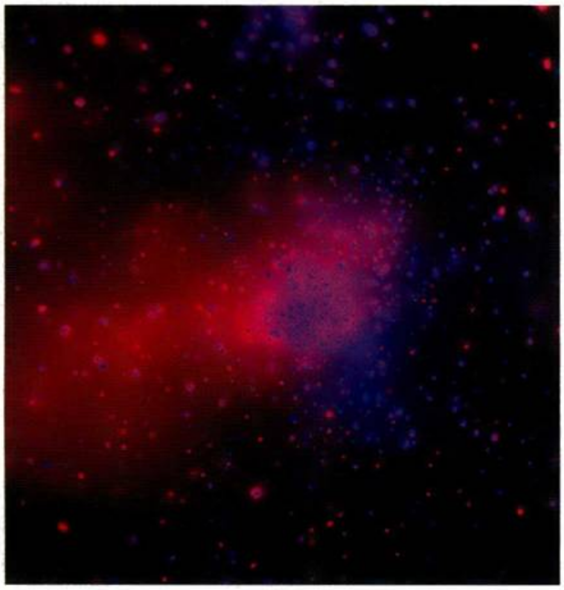
ARE PLANETS WITH LARGE AXIAL TILTS HABITABLE? Computer simulations show that an Earth with even an 85° tilt to its axis could retain life given its current geography, although seasonal variations in temperature would be more extreme than now.

{ 12:03 }

STAR-FORMING REGIONS

M17's champagne x rays

Astronomers using the Chandra X-ray Observatory have detected very high-temperature gas flowing away from hot, young, massive stars in the core of the Omega Nebula (M17) in Sagittarius. The gas ranges in temperature from about 1.5 million kelvins (2.7 million degrees Fahrenheit) to 7 million kelvins (13 million degrees Fahrenheit).



HOT STARS AND GAS SHINE PINK in this false-color image showing the heart of the Omega Nebula as seen by the Chandra X-ray Telescope. NASA/CFA

The hot gas detected by Chandra lies inside the loop of nebulosity that gives the nebula its nickname. This loop is familiar to many backyard astronomers because it's visible with even a small telescope. According to Chandra's astronomers, the massive stars in the nebula are only about a million years old, and not one has exploded yet as a supernova.

Looking for mechanisms to boost the gas to such high temperatures, the astronomers think it might be heated as the hot stars blow off high-velocity "winds" of particles. These collide with similar winds from other hot stars nearby. Another mechanism that may be working simultaneously is heating the cooler nebular gas through collisions with the winds. Studies of other nebulae show hot gas where many massive stars exist and cooler gas where such stars are rare.

In any case, the hot gas appears to be flowing out of M17's horseshoe-shaped loop like champagne flowing from a newly opened bottle. — **R. B.**

GAMMA-RAY BURSTS

Amateur beats pros

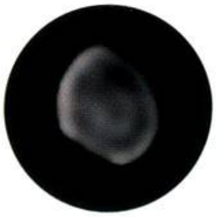
On July 25, 2003, Berto Monard of South Africa became the first amateur astronomer to discover the afterglow of a gamma-ray burst, the most powerful explosion known in the universe.

Monard notified the American Association of Variable Star Observers of the position of the event (now known as GRB030725) only seven hours after receiving an alert from the High-Energy Transient Explorer satellite, which had detected a 40-second burst.

Monard imaged the area with a CCD camera attached to his 12-inch Schmidt-Cassegrain telescope. "I started to take unfiltered CCD images of the field, acquiring one image every minute. Early in the evening, the object was magnitude 18.8, but it faded to 19.6 by night's end. After the third set of images, I was certain I had found the afterglow." — MICHAEL BAKICH

PLANETARY SCIENCE

Keck shoots minor planet



ASTEROID DAVIDA displays a smooth and gently irregular profile. KECK OBSERVATORY

A big telescope with adaptive optics enabled planetary scientists to photograph the main-belt asteroid (511) Davida. The images show Davida's northern hemisphere because its north pole was pointed toward Earth at the time.

"Minor planet Davida was discovered 100 years ago," says Keck Observatory astronomer Al Conrad. "But this is the first time we have been able to see this detail."

A team led by William Merline (Southwest Research Institute) used adaptive optics to sharpen the images taken through the 10-meter Keck II telescope.

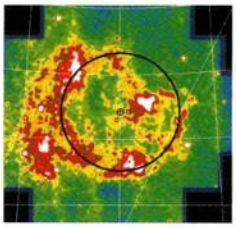
Davida has a diameter of about 200 miles (320 km), and its smallest details are about 30 miles (45 km) across.

While Davida is generally round in shape, it still has a somewhat irregular outline. The observations also revealed a few darker areas that planetary scientists will investigate further. These could be exposures of different minerals on its surface or perhaps topographic relief. — **R. B.**

STELLAR ASTRONOMY

Pulsar distance links to remnant

Pinpointing the distance to a pulsar has let astronomers link it to a nearby supernova remnant, according to a report from the Very Long Baseline Array radio telescope.



A RING OF X RAYS from a supernova surrounds a pulsar. MAX-PLANCK-INSTITUT

The pulsar, designated PSR B0656+14, lies in Gemini. Using indirect methods, astronomers concluded that it lay about 2,500 light-years away. A nearby supernova remnant, however, was known to be less than half that distance, only 1,000 light-years off.

Astronomer Walter Brisken used the VLBA to make high-precision position measurements of the pulsar. By detecting a small offset that repeated annually due to Earth's motion, his team found that the pulsar is actually only 950 light-years away, tying it to the supernova remnant.

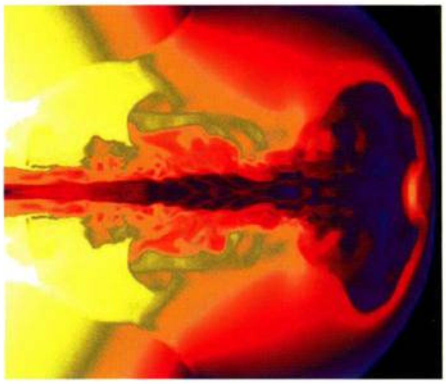
Astronomers had observed cosmic rays coming from a supernova that blew up 100,000 years ago at a distance of a thousand light-years. They now suspect that the newly linked pulsar may have been the source. — **R. B.**

ULTRA HIGH-ENERGY COSMIC RAYS

Fast and furious

Archived data from NASA's Compton Gamma Ray Observatory have given researchers a possible link between the most powerful explosions in the universe — gamma-ray bursts (GRBs) — and its most energetic particles known, ultra high-energy cosmic rays.

On October 17, 1994, the orbiting observatory picked up a GRB that triggered onboard detectors sensitive to both low- and high-energy gamma-ray photons. While the flow of low-energy photons behaved as predicted, fluctuating wildly during about 100 seconds, the flow of those at high-energy stayed relatively constant for twice as long.



PARTICLES TRAVELING nearly as fast as light shoot out of a gamma-ray burst in this computer simulation. WEIQUN ZHANG AND STAN WOOSLEY, LBL

"It's quite unanticipated theoretically," says astrophysicist Robert Preece (University of Alabama), one of the authors of an August 14 *Nature* report on the burst. Some complicated particle physics may provide an explanation.

GRBs are associated with the explosive deaths of massive stars, (see News, October 2003). The ferocity of the event results in blast waves and powerful magnetic fields that may accelerate charged particles such as protons and electrons to near-light speeds. The ultra high-energy cosmic rays, most relativistic protons, could slam into photons, giving them gamma-ray energies. — **MAGGIE McKEE**

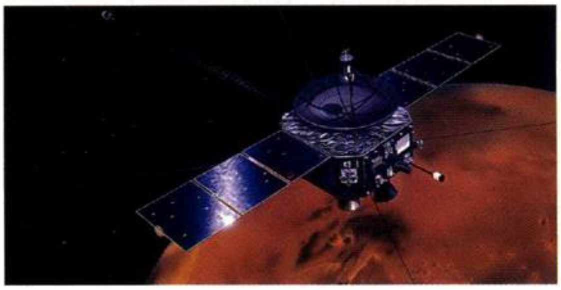
The Mars mission no one knows about

Sometime over the 2004 New Year holiday, a battered Japanese space probe named Nozomi will arrive at Mars after a five-year voyage. It may enter orbit successfully and begin scientific observations — or it might sail on past into the infinite darkness. This is a cosmic cliffhanger because we probably won't know the outcome until Nozomi actually arrives.

When launched on July 4, 1998, Nozomi was supposed to reach Mars by the end of 1999. It carried a camera and a dozen other instruments to study the martian upper atmosphere.

At first, it cruised in an elongated Earth orbit, picking up energy through several swingbys of the Moon. Then on December 20, 1998, after passing within 600 miles of Earth's surface, Nozomi fired its main engine and thrust itself toward Mars.

Unfortunately, something went wrong and Nozomi wound up so far off course that two quick corrective burns had to be made the following day. By the time it was back on course, Nozomi no longer had enough fuel to brake itself into martian orbit. So when it reached Mars in October 1999, Nozomi flew on past.



PLAGUED BY TECHNICAL TROUBLES, Japan's Nozomi spacecraft will approach Mars in early 2004. If it achieves orbit, Nozomi will join a small spacecraft armada already there. ISAS

Creative space navigators worked out a flight path that would bring Nozomi back to Mars again, but with a slower approach speed. This required four more years of coasting through space, including a pair of Earth flyby maneuvers in December 2002 and June 2003.

Along the way, another crisis struck. On April 21, 2002, Nozomi was hit by a massive solar flare that crippled its power system. Drifting far from the Sun without heaters, the craft's hydrazine fuel tanks froze up. Although the spacecraft later thawed enough to use the fuel for a rocket firing (unlike water, hydrazine does not expand destructively when it freezes), mission managers in Japan knew the fuel would freeze again before the craft's arrival at Mars.

The power also had to be fixed. The camera still can take pictures, for instance, but the radio lacks enough power to send a readable signal back to Earth.

To restore the power control system, engineers planned to cycle the on-off switch several hundred times in the weeks just after the last Earth flyby (June 2003), when Nozomi was nearest the Sun and thus receiving the greatest amount of electrical power. But as week followed week into the autumn, there was no happy news from Japan.

As Nozomi moves away from the Sun and power and warmth drop, the race between long-distance repair and the harsh conditions of deep space will come down to how soon — and how much of — the fuel freezes. If nothing else goes wrong — that is, if the probe's luck changes for the better — it may become a case study in perseverance and persistence. Otherwise, it will take its place as another sad setback, a casualty of Earth's struggle to expand our senses and our consciousness into the universe.

— **JAMES OBERG**

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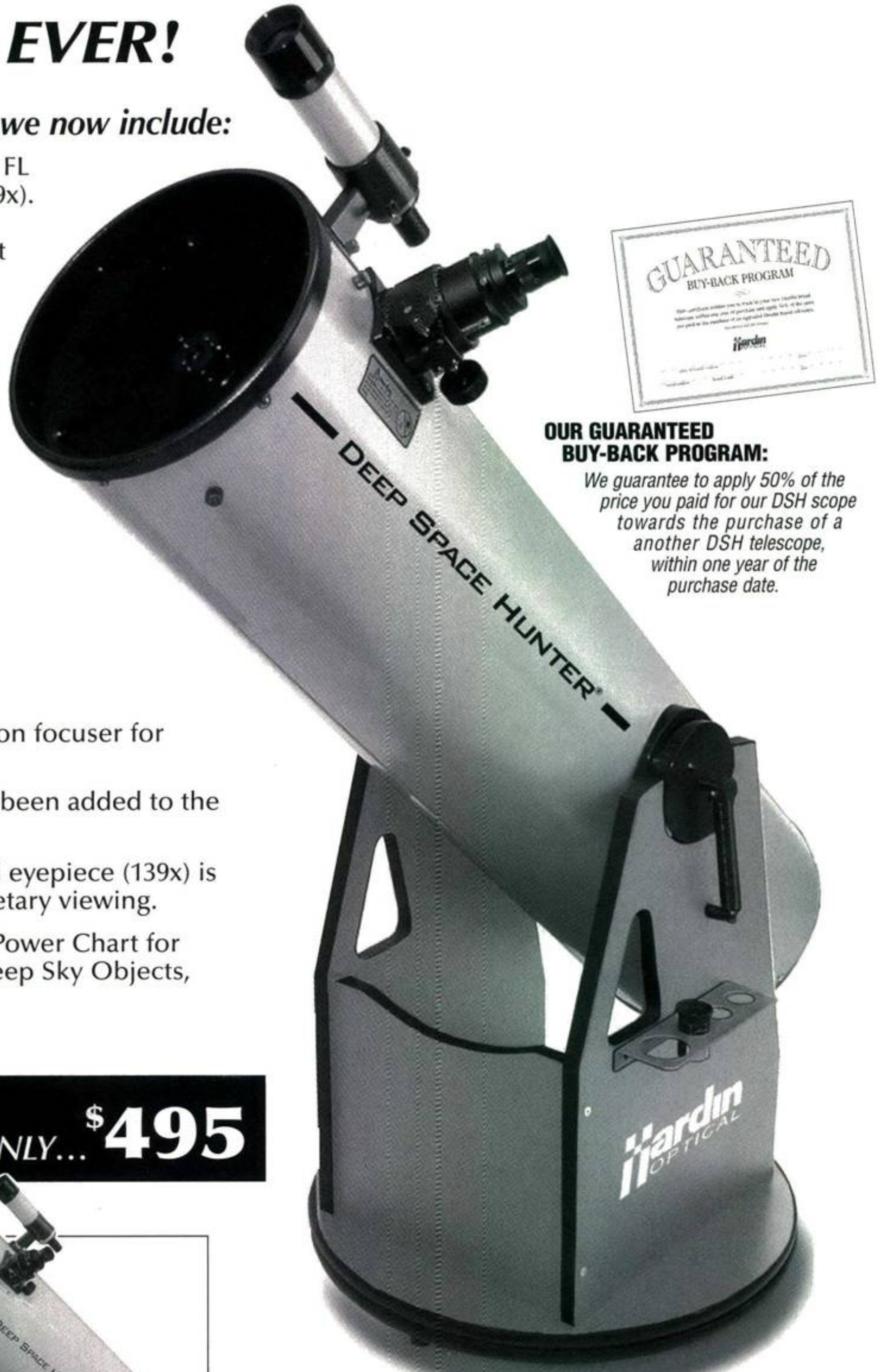
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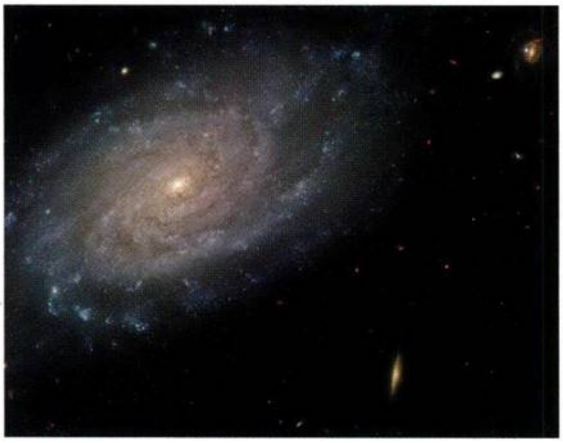
THE UNIVERSE IS SLOWLY FADING INTO DARKNESS as stars grow old and burn out. A new study conducted by the Sloan Digital Sky Survey has found that in the current epoch of the universe, stars are dying faster than new ones are being born.

HUBBLE HERITAGE IMAGE

NGC 3370: giant spiral



HOT BLUE CLUSTERS OF STARS mingle with dark lanes of dust and a small central nucleus in the giant spiral galaxy NGC 3370 in Leo. NASA/STScI/HUBBLE HERITAGE TEAM

The spiral galaxy NGC 3370 lies 98 million light-years from Earth in the constellation Leo the Lion. It glows softly at magnitude 12.3 and is visible through backyard telescopes with apertures of 10 inches or more.

Laden with dust and hydrogen gas, the galaxy is a beautiful example of nature's star-making factories. In November 1994, a star exploded here, briefly outshining all the galaxy's other stars. It was a type Ia supernova, the kind of explosion astronomers use to gauge the size and scale of the universe.

Type Ia supernovae occur when one star in a binary pair becomes a red giant and begins to dump gas onto its white dwarf companion. When the white dwarf accumulates more than 1.4 times the mass of the Sun — bang! It detonates as a supernova whose light fades in a characteristic pattern.

Astronomers like type Ia supernovae because they all have about the same brightness. This means astronomers can measure the distance to the star's host galaxy by measuring the supernova's apparent brightness. Studies of type Ia supernovae have shown that, for reasons not yet understood, the expansion of the universe is accelerating.

NGC 3370 also contains the most distant Cepheid variable stars ever measured. Astronomers can use Cepheids as distance indicators only over relatively short distances because they glow dimly.

The upper corner of the image holds a contorted pair of colliding galaxies. A bright barred spiral galaxy appears to be tearing apart a smaller galaxy, probably a dwarf. — **R. B.**

SOLAR SYSTEM

Early Mars cold, dry?

The early martian climate was probably not warm and wet, say researchers using the Mars Global Surveyor spacecraft.

A team of Arizona State University scientists reports discovering lots of carbonate minerals on Mars — but not in massive outcrops.

"We have found carbonates, but only trace amounts," says planetary scientist Phil Christensen. Carbonate minerals form easily in the presence of water and carbon dioxide.

If Mars once had large bodies of liquid water, it should have produced lots of carbonate rock, like limestone. But the carbonates found probably formed as water vapor in the air mixed with the ever-present dust.

"This seems to be the result of a thin atmosphere interacting with dust," says Christensen, "not oceans interacting with a big, thick atmosphere." — V. T.

SOLAR SYSTEM

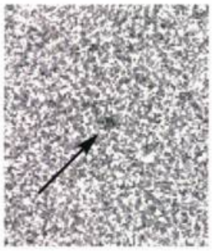
Halley's Comet caught

It took three large telescopes working together, but Comet 1P/Halley is now the farthest and faintest comet ever observed.

Three of the four 8.2-meter members of the Very Large Telescope array in Chile photographed the comet when it was 2.6 billion miles (28.06 AU or 4.2 billion kilometers) from the Sun, almost to Neptune. The comet glowed faintly at magnitude 28.2, a billion times too faint for the naked eye.

The observations show no sign of activity. Halley's brightness is exactly what scientists expected, assuming that its 6-mile-long (10-km), lumpy nucleus is bare.

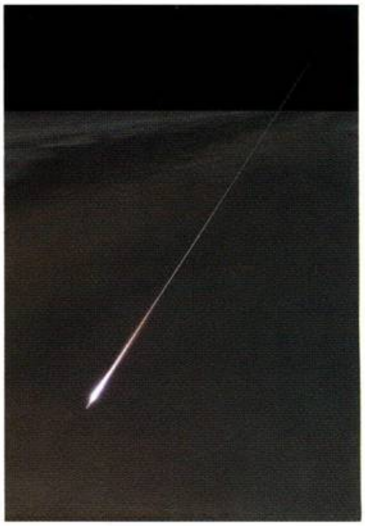
Scientists also expect to follow Halley through the farthest point in its orbit, to be reached by the comet in late 2023. — **V. T.**



COMET HALLEY glows faintly at 28th magnitude. ESO

SOLAR SYSTEM

Galileo mission ends in glory



GALILEO dives into Jupiter. ADOLF SCHALLER

The Galileo mission concluded on September 21, 2003 as the spacecraft made a fiery final plunge into the atmosphere of Jupiter.

Galileo, launched in 1989, had been orbiting Jupiter since December 1995. On arrival, it dropped a probe into Jupiter and made a total of 35 orbits around the giant planet, photographing in great detail its cloudbelts and the four major satellites: Io, Europa, Ganymede, and Callisto.

Galileo's many discoveries include high-temperature volcanism on Io, a suspected ocean under Europa's icy crust, and a magnetic field at Ganymede. — **R. B.**

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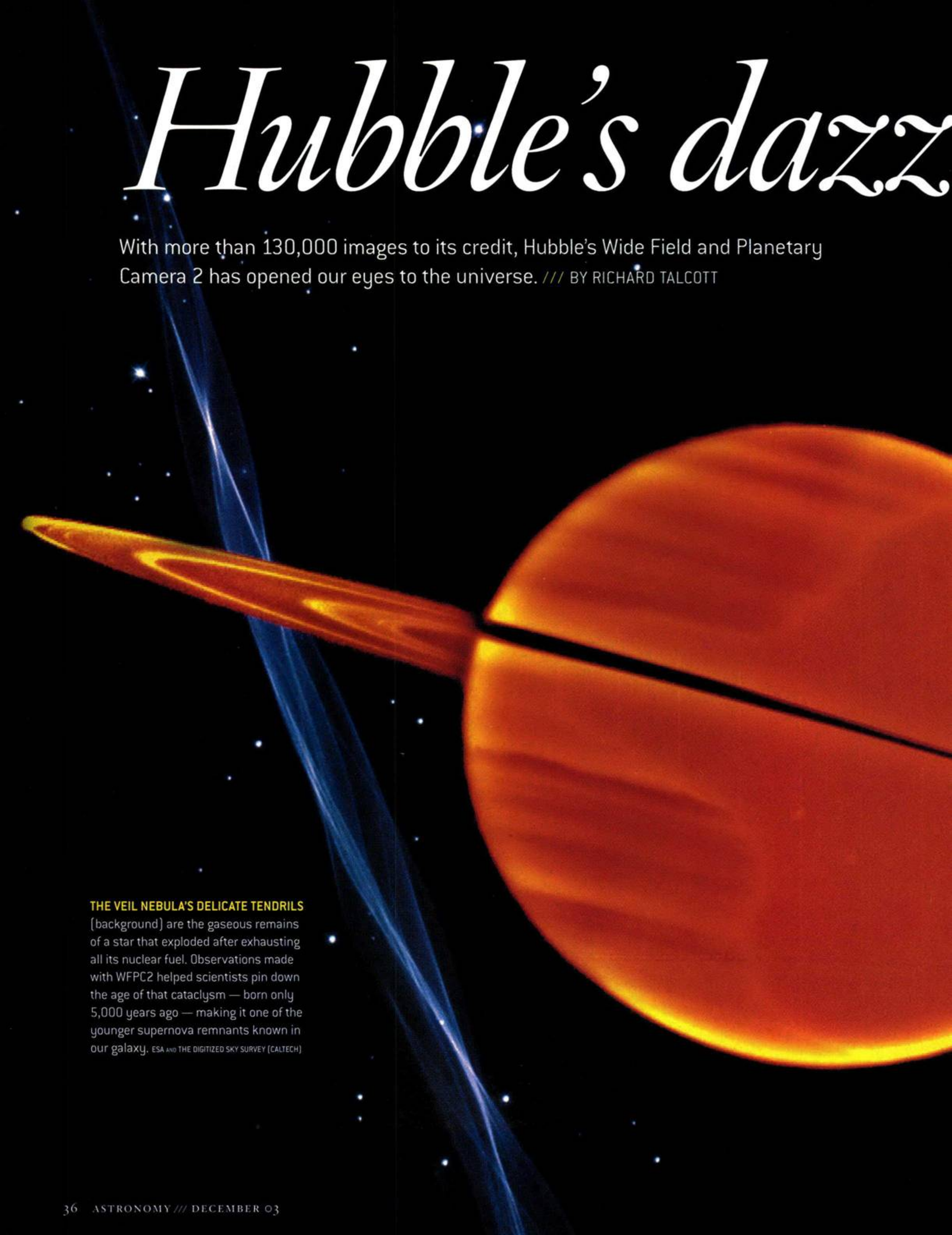
Hubble's dazz

With more than 130,000 images to its credit, Hubble's Wide Field and Planetary Camera 2 has opened our eyes to the universe. /// BY RICHARD TALCOTT



THE VEIL NEBULA'S DELICATE TENDRILS (background) are the gaseous remains of a star that exploded after exhausting all its nuclear fuel. Observations made with WFPC2 helped scientists pin down the age of that cataclysm — born only 5,000 years ago — making it one of the younger supernova remnants known in our galaxy. ESA AND THE DIGITIZED SKY SURVEY (CALTECH)

ling decade

The calendar may say only ten years have passed, but it seems nearly a lifetime. December 1993 marked a turning point both in the history of astronomy and for NASA. The space agency had a lot riding on STS-61 — its code for the first Hubble Servicing mission — and failure was not an option.

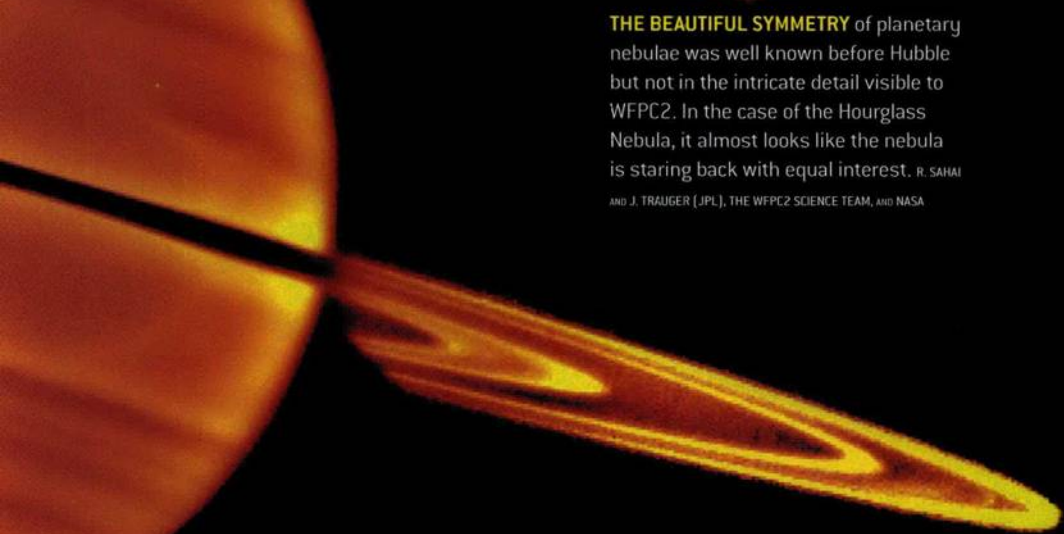
Great hoopla surrounded the deployment of the Hubble Space Telescope back in April 1990. Lifted above the distorting effects of Earth's turbulent atmosphere, the school-bus-size orbiting observatory promised clearer views of the heavens than humans had ever seen. But within weeks, that promise had turned to disaster: Initial images showed a problem with the main mirror that prevented the telescope from focusing light sharply. And NASA couldn't afford having a multi-billion-dollar white elephant endlessly circling Earth.

Fortunately, Hubble was designed to be serviced regularly. On December 2, 1993, a team of seven astronauts rocketed into space onboard the space shuttle Endeavour. They had a multitude of tasks to perform: replace the twin solar arrays, which jittered every time the telescope crossed from sunlight to darkness and back again; replace three failing gyroscopes needed to help point the telescope; replace fuses and magnetometers; fix a power-supply problem; and boost the observatory to a higher orbit so it wouldn't suffer as much atmospheric drag.

None of these fixes much helped Hubble's blurry vision, however. The solution to that problem rested on two ingenious new instruments. The Wide Field and Planetary Camera 2, or WFPC2 (pronounced "wif-pik-2"), contains corrective lenses that precisely compensate for the primary mirror's deficiency. Like a pair of eyeglasses, the lenses transformed fuzzy images into crystal clarity, allowing Hubble to reach its initial lofty expectations. The second instrument — the Corrective Optics Space Telescope Axial Replacement, or COSTAR —

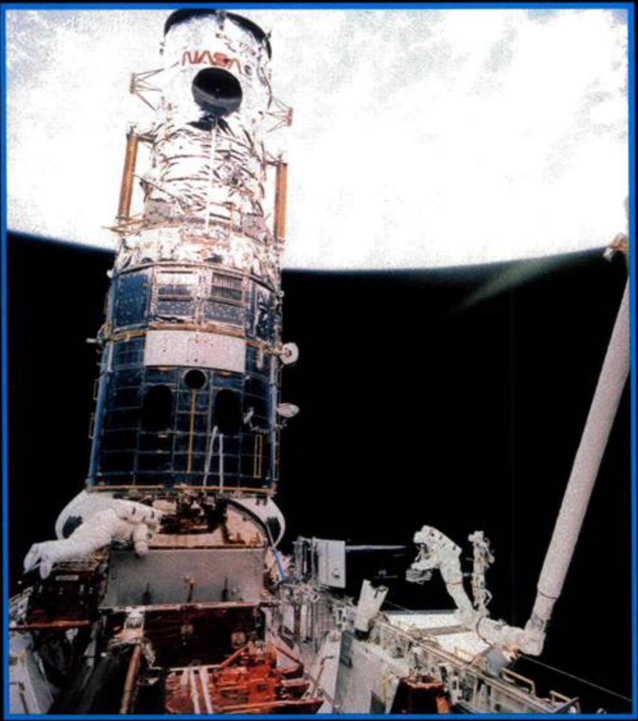
Richard Talcott is senior editor of *Astronomy*.

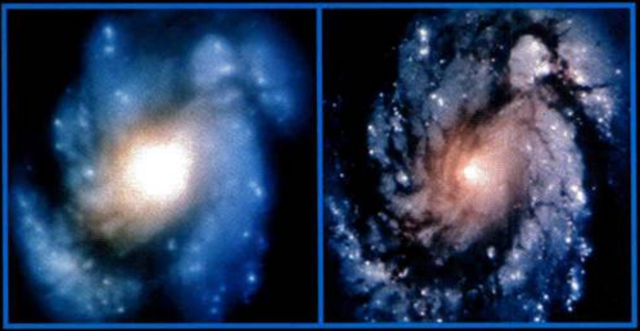
THE BEAUTIFUL SYMMETRY of planetary nebulae was well known before Hubble but not in the intricate detail visible to WFPC2. In the case of the Hourglass Nebula, it almost looks like the nebula is staring back with equal interest. R. SAHAI AND J. TRAUGER (JPL), THE WFPC2 SCIENCE TEAM, AND NASA

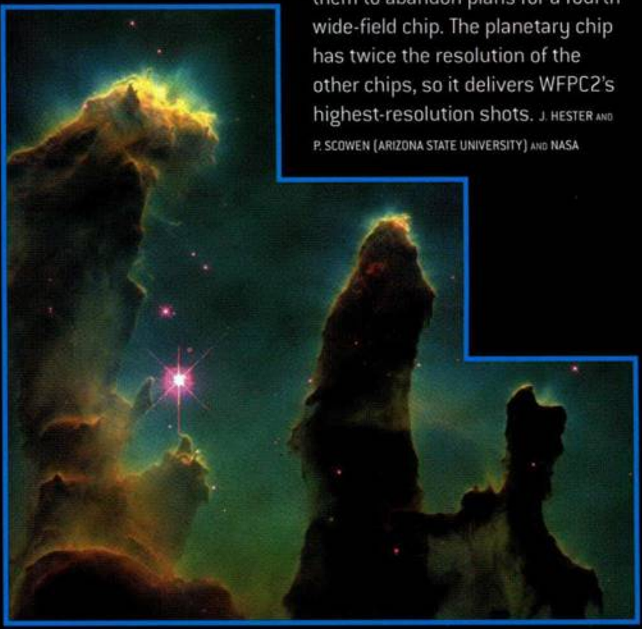


SATURN'S RINGS took on a new appearance when Hubble viewed them during the 1995 ring-plane crossing. With the Sun below the ring plane and Earth above, WFPC2 saw light scattered by the tenuous, inner C ring, the Cassini division separating the A and B rings, and the outermost F ring — but little light through the thicker A and B rings. P. NICHOLSON (CORNELL UNIVERSITY), S. LARSON (UNIVERSITY OF ARIZONA), AND NASA

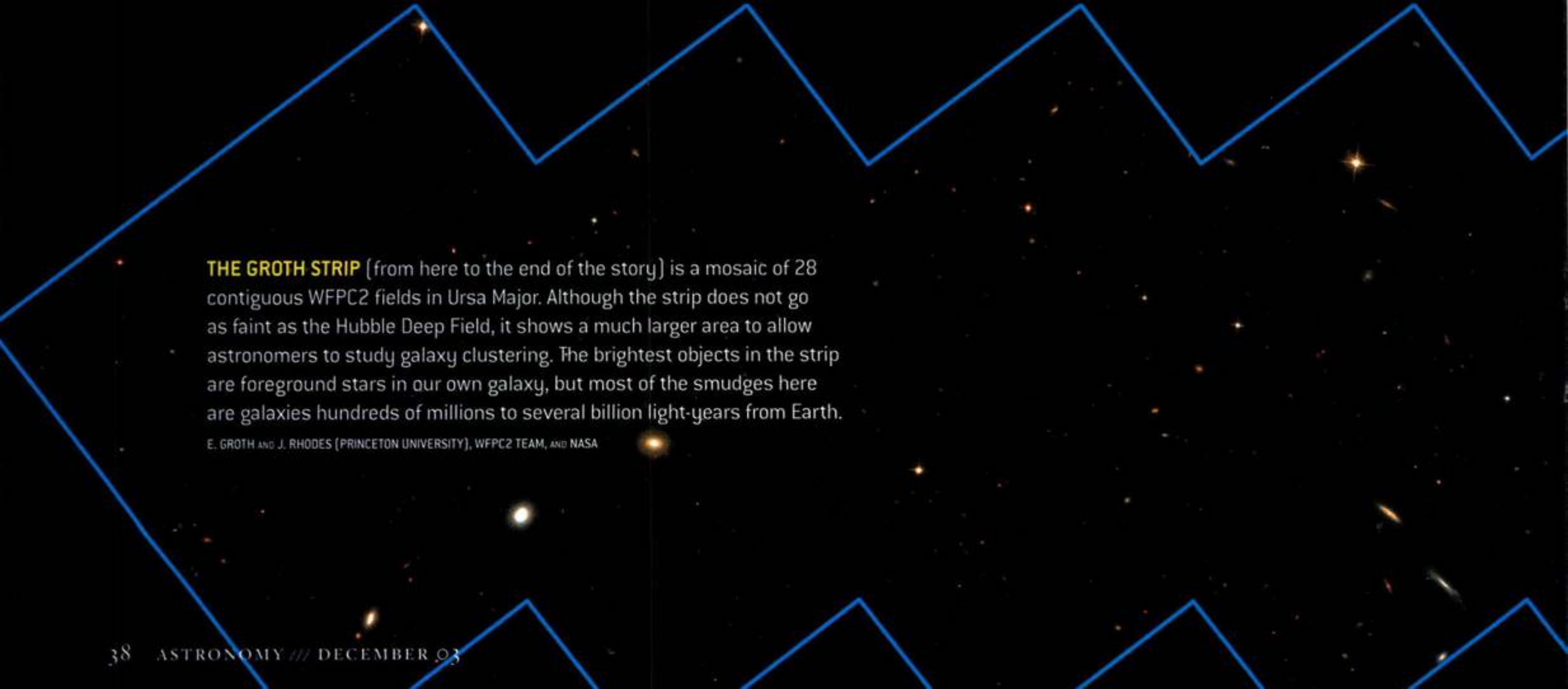
/// MYOPIA, BAT-WINGS, AND BEAUTY







ASTRONAUT JEFFREY HOFFMAN (left, attached to the space shuttle's robot arm) prepares to stow the original Wide Field and Planetary Camera 1. He and fellow astronaut Story Musgrave had just installed WFPC2 during the December 1993 servicing mission. Because Hubble's primary mirror had been ground to the wrong shape, the telescope blurred starlight, smeared fine detail, and had a limited ability to see faint structure. NASA **THERE'S NO COMPARISON** between images of spiral galaxy M100 taken with WFPC1 (bottom left, at left) and WFPC2 (to its right). The corrective lenses incorporated into WFPC2 completely cured Hubble's blurred vision. NASA **THE "PILLARS OF CREATION"** (below) in the Eagle Nebula became the most widely recognized photo ever taken by Hubble. It also shows the famous (some would say infamous) "bat-wing" shape of WFPC2 images. The camera features four CCD chips: three wide-field chips and one planetary chip (the smaller square at upper right). The camera's makers faced budget constraints that forced them to abandon plans for a fourth wide-field chip. The planetary chip has twice the resolution of the other chips, so it delivers WFPC2's highest-resolution shots. J. HESTER AND P. SCOWEN (ARIZONA STATE UNIVERSITY) AND NASA

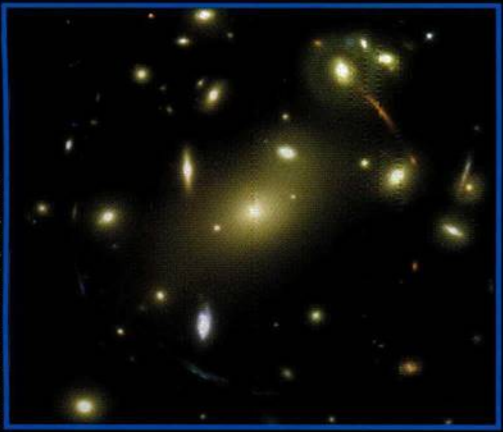


THE GROTH STRIP (from here to the end of the story) is a mosaic of 28 contiguous WFPC2 fields in Ursa Major. Although the strip does not go as faint as the Hubble Deep Field, it shows a much larger area to allow astronomers to study galaxy clustering. The brightest objects in the strip are foreground stars in our own galaxy, but most of the smudges here are galaxies hundreds of millions to several billion light-years from Earth. E. GROTH AND J. RHODES (PRINCETON UNIVERSITY), WFPC2 TEAM, AND NASA focused the light reaching Hubble's other instruments.

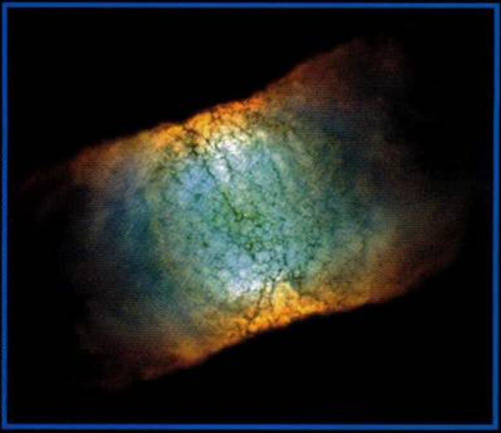
But today we sing the praises of WFPC2. In the ten years since astronauts Jeff Hoffman and Story Musgrave installed the camera, it has returned some 135,000 images of the universe. It has scrutinized Earth's nearest celestial neighbor, the Moon. It took the deepest image ever of the cosmos, the legendary Hubble Deep Field. (Although that record has been eclipsed in recent images from a newer Hubble instrument, the Advanced Camera for Surveys.) And it has studied myriad examples of almost every type of object that lies between.

Observations made with WFPC2 pinned down the distance scale of the universe by monitoring Cepheid variable stars as far away as the Virgo Cluster of galaxies. The camera helped astronomers prove that quasars are active centers of distant galaxies, many of which appear to be interacting with other galaxies. It surveyed the environs of young stars and showed that protoplanetary disks shooting out jets of material surrounded many of them. It helped prove that gamma-ray bursts occur in distant galaxies and rank as the brightest objects in the cosmos.

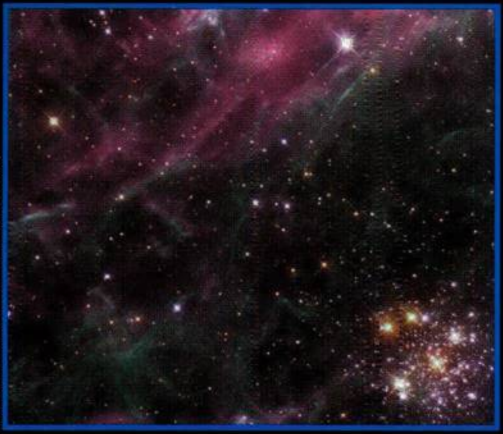
One of its greatest and most unexpected triumphs came through observations of supernovae located halfway to the edge of the universe. Working in


A. FRUCHTER AND THE ERO TEAM (STScI) AND NASA

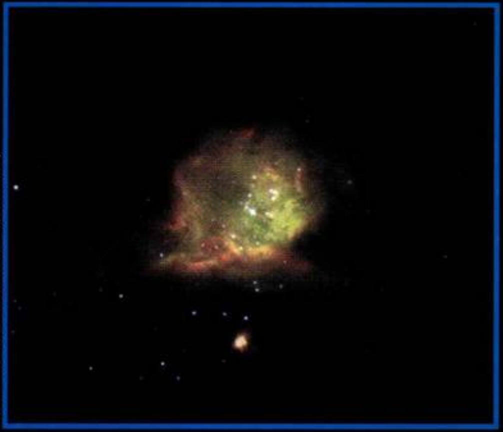
ARCS AND SCRAPS of remote galaxies showed up against the foreground galaxies in the rich cluster Abell 2218 when Hubble snapped this portrait. As Einstein predicted, high mass concentration bends light from more distant objects, creating weird optical effects.


NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

PLANETARY NEBULA IC 4406 shows that stars often go out in a blaze of glory. When a Sun-like star reaches the end of its life, it puffs off its outer layers. The white-hot core of the star left behind excites the expelled gas, causing it to glow.

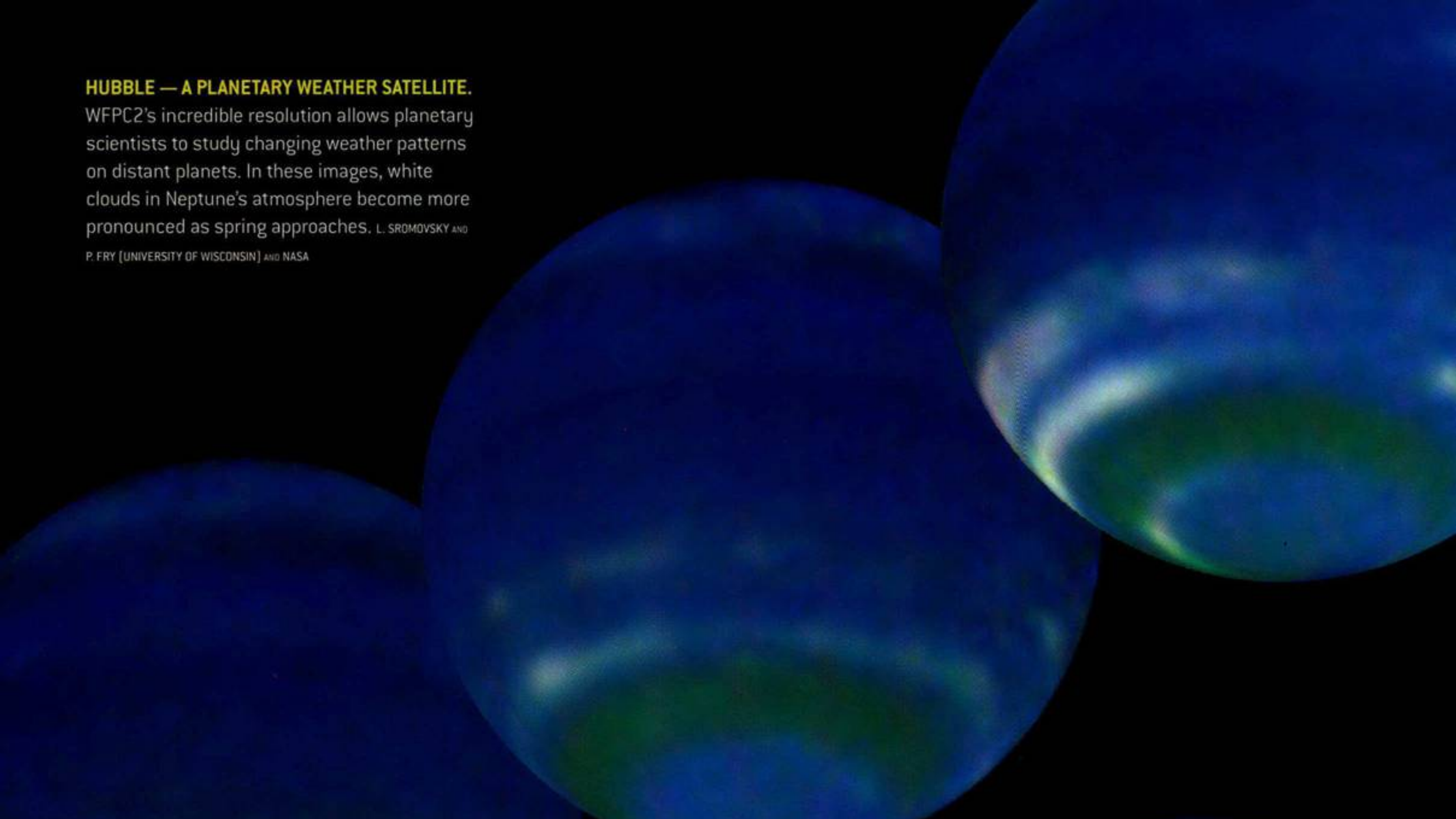

NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

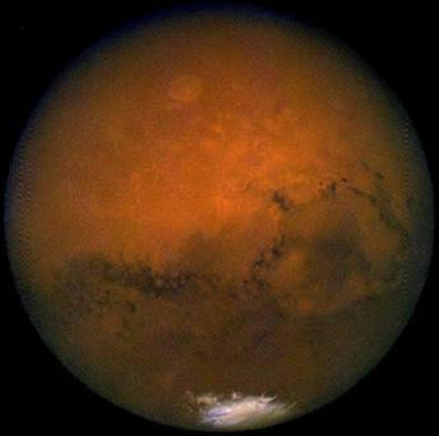
A CLUSTER OF MASSIVE STARS known as Hodge 301 (lower right) lies in the Large Magellanic Cloud's Tarantula Nebula. The image shows just a tiny portion of the Tarantula. Many of Hodge 301's stars have gone supernova, sculpting the multitude of filaments seen nearby.


NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

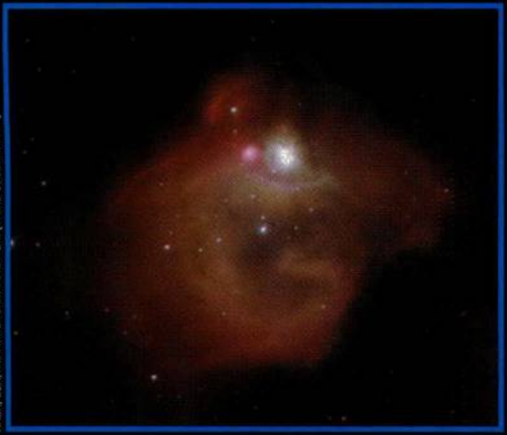
A DRAMATIC BURST OF STAR FORMATION highlights the emission nebula dubbed "Hubble-X," located in the Local Group galaxy NGC 6822. Hubble-X dwarfs our galaxy's Orion Nebula — the tiny cloud below the image's center is about as big and bright as Orion.

HUBBLE — A PLANETARY WEATHER SATELLITE. WFPC2's incredible resolution allows planetary scientists to study changing weather patterns on distant planets. In these images, white clouds in Neptune's atmosphere become more pronounced as spring approaches. L. SROMOVSKY AND P. FRY (UNIVERSITY OF WISCONSIN) AND NASA

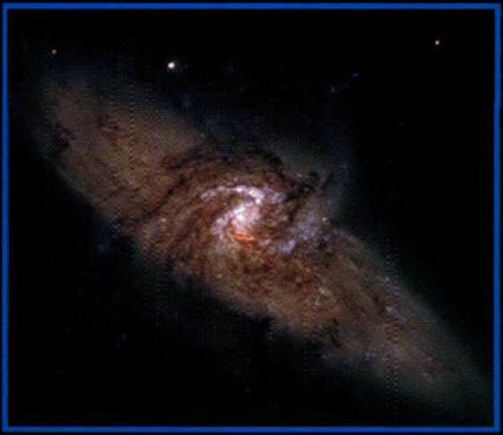




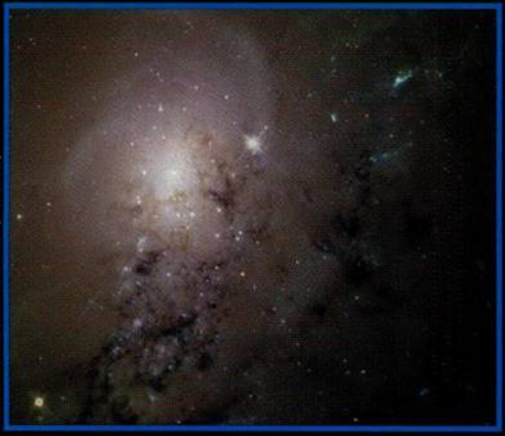
THE RED PLANET posed for WFPC2 on August 27, when Mars was at its closest to Earth in nearly 60,000 years. The south polar cap (bottom) and volcano Olympus Mons (oval above center) stand out. NASA, J. BELL (CORNELL UNIVERSITY), AND M. WOLFF (SSI)


NASA, ESA, AND M. HEYDARI-MALAYERI (PARIS OBSERVATORY)

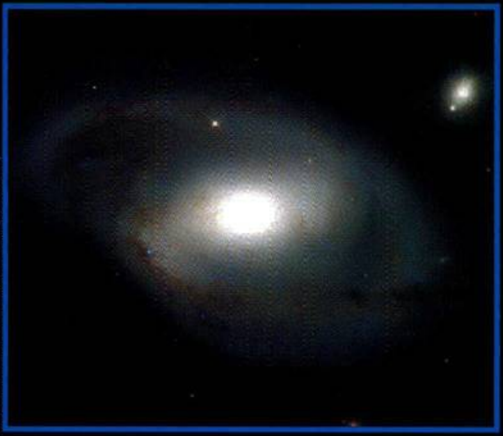
A SPHERICAL BUBBLE lies at the center of N83B, an emission nebula in the Large Magellanic Cloud. The star blowing the bubble is the innocuous-looking one at the nebula's center; the star has about 30 times the Sun's mass. A brighter star lies just above the nebula's center.


NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

INTERACTING GALAXIES FILL THE COSMOS — but this isn't one of them. The pair of galaxies that make up NGC 3314 actually form a chance alignment. Dark dust lanes in the foreground galaxy appear in silhouette against the bright regions of the more distant one.


NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

DRAMATIC DUST LANES and blue regions of star birth mark the site where a foreground spiral galaxy is colliding with a giant elliptical (NGC 1275) at the center of the rich Perseus Cluster of galaxies. The collision feeds a supermassive black hole at the center of NGC 1275.


NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

A CHANCE ALIGNMENT places the nearby spiral NGC 4319 next to the distant quasar Markarian 205 (upper right). This image shows only the inner regions of NGC 4319, which lies 80 million light-years from Earth. Markarian 205 resides a billion light-years farther away.

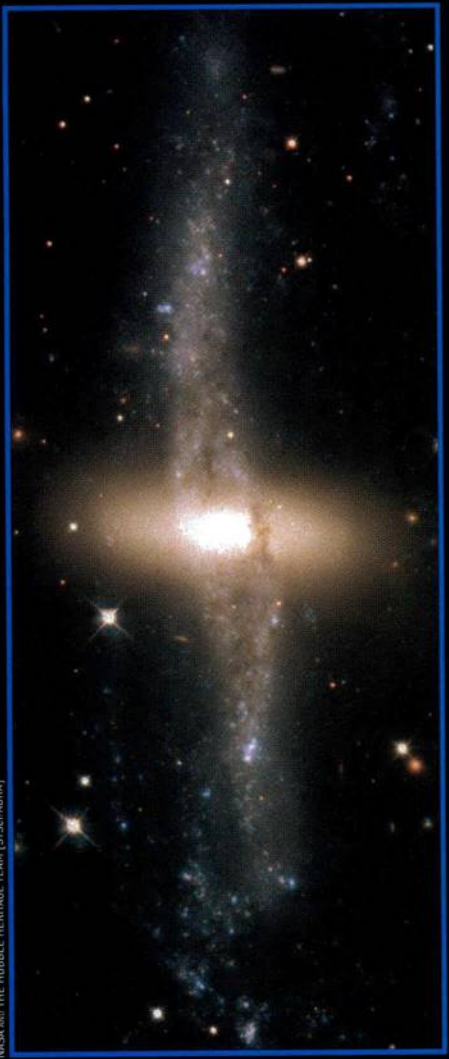
tandem with large ground-based telescopes (which couldn't view the most distant supernovae clearly through Earth's atmosphere), these studies showed that some mysterious force — a "dark energy" — was causing the cosmos to expand at an ever-increasing rate.

Yet to many people, the chief legacy of WFPC2 lies in the beauty of its images. Whose jaw failed to drop when seeing the pillars of gas and dust in the Eagle Nebula for the first time? You could almost see individual stars beginning to form in parts of the nebula, while blazing hot, newborn suns evaporated gas and dust in other regions. Studying the opposite end of a star's life, WFPC2 chronicled the intricate symmetry of planetary nebulae, objects formed when Sun-like stars puff off their outer layers as they exhaust their nuclear fuel. Nearly every image seems to have its own special charm, no doubt because it reflects the beauty inherent in nature.

WFPC2's stunning success came about partly in response to Hubble's optical problem. The telescope's primary mirror, 2.4 meters (94 inches) in diameter, was polished to near perfection. If the mirror were scaled to the size of Earth, the biggest bump or dip would measure just 6 inches. Yet the mirror was ground to the wrong shape: Its edges were flat by 2 microns, about 1/50 the width

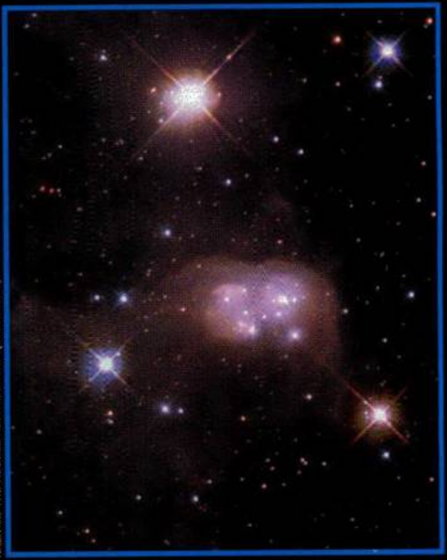
NASA, R. WINDHORST (ARIZONA STATE UNIVERSITY) AND THE HUBBLE MID-UV TEAM

THESE THREE NEARBY GALAXIES look rather odd because Hubble viewed them in the ultraviolet. Astronomers surveyed 37 nearby galaxies to compare them with distant galaxies, whose ultraviolet emission has been redshifted to the visible.



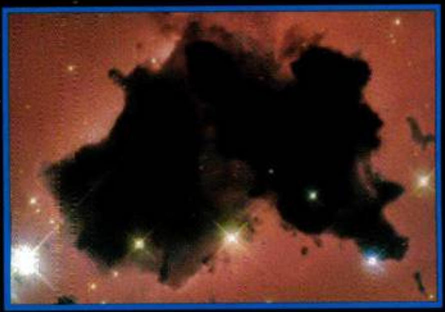
NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

POLAR RING GALAXY NGC 4650A formed more than a billion years ago when a small galaxy collided with a big one. The large galaxy stripped gas from the intruder and ultimately created a ring of gas, dust, and stars perpendicular to its own disk.



NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

A PEANUT-SHAPED COCOON of dust dubbed the "Double Bubble" surrounds a cluster of hot, young stars in the Large Magellanic Cloud. The bubble has been cataloged as N30B, while the nebula filling most of the frame goes by DEM L 106.



NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

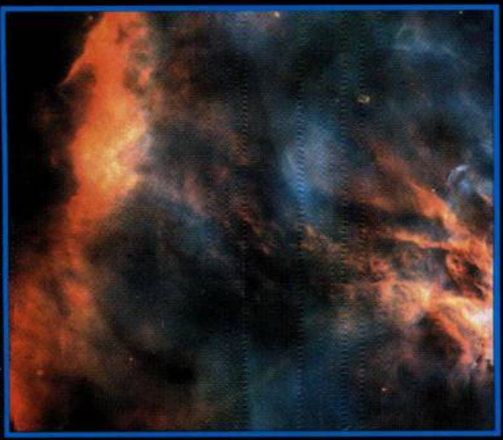
DENSE, OPAQUE DUST CLOUDS known as globules stand out against the glowing background of the emission nebula IC 2944. Hubble's resolution shows that the largest globule actually consists of two smaller, overlapping dust clouds.

of a human hair. Hubble's mountain of trouble arose from that tiny molehill. (Although a fairly robust molehill — in our example of an Earth-size mirror, the edge would be 35 feet too low.)

Fortunately, the engineers who worked with Hubble were able to characterize the mirror's flaw precisely, allowing the team at NASA's Jet Propulsion Laboratory that was building WFPC2 to design the right prescription. Mission planners always intended to replace the original Wide Field and Planetary Camera on the first servicing mission to take advantage of improvements in technology. They simply incorporated corrective lenses into the new design.

The camera can detect radiation from the ultraviolet to near-infrared part of the electromagnetic spectrum. It also can use any of 48 different filters to isolate certain wavelengths. All of WFPC2's color images were made by combining observations at multiple wavelengths. Often, astronomers using Hubble create images that closely match what the human eye would see, but many pictures don't.

Whatever color scheme astronomers choose, the results say something special scientifically — and often visually. So sit back and recall some of the highlights from the past decade, and imagine what treats WFPC2 still has in store. ▣



C. R. O'DELL (RICE UNIVERSITY) AND NASA

GAS, DUST, AND NEWBORN STARS make up the Orion Nebula (M42), the most famous region of star formation in our galaxy. In this view, you can see several lower-mass stars surrounded by disks of gas and dust about twice the size of our solar system.

H. YANG (UNIVERSITY OF ILLINOIS) AND NASA

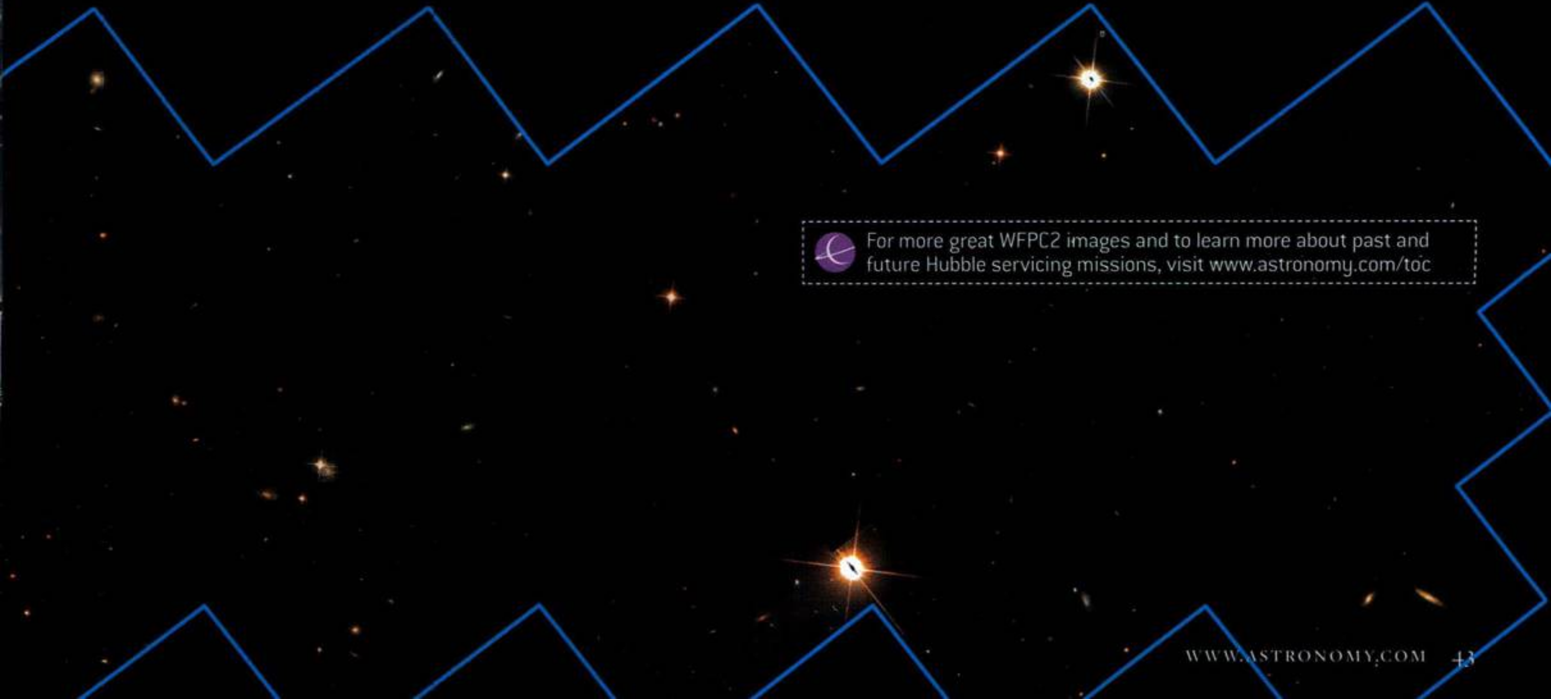
THE STELLAR NURSERY NGC 604 lies in a spiral arm of M33, a Local Group galaxy also known as the Pinwheel. This nebula is especially big and bright, spanning 1,500 light-years and containing more than 200 young, hot stars with masses more than 15 times that of the Sun.

NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

A BOW SHOCK created by the star LL Orionis (center) is but one of many in the Orion Nebula. The crescent-shape bow shock forms where the star's vigorous stellar wind collides with slower-moving gas evaporating from the nebula's center (beyond the lower right edge).

R. WILLIAMS (STScI), THE HUBBLE DEEP FIELD TEAM, AND NASA

THE HUBBLE DEEP FIELD was, at the time, the deepest image ever of the cosmos. Taken over ten days and reaching to magnitude 30, it gave astronomers a snapshot of several thousand galaxies as they existed when the universe was just 10 percent of its present age.



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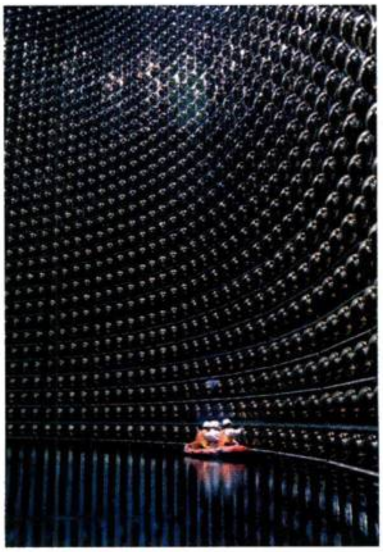
Ghostbusting the Universe

A physicist invented neutrinos to make an equation work. Then they turned out to be real. Now scientists think they offer clues to other dimensions. /// BY ALISON BOYLE AND KEN GRIMES

Elusive, intangible, mysterious. For three quarters of a century, neutrinos have proven the most ghostly of all the quantum entities that make up the universe. As physicist Ray Davis, Jr., explains, "A neutrino passing through Earth has only one chance in a thousand billion of being captured." Yet for all neutrinos' difficulty of detection and bizarre behavior, new theoretical work suggests that understanding them will help lead physics to a Theory of Everything.

Meanwhile, the specter of the neutrino has haunted not only individual physicists and astronomers, but humanity's best attempt to sketch the deep workings of the cosmos, the Standard Model of particle physics. Dedicated teams of scientists — cosmic ghostbusters — have pursued this insubstantial presence, rewarded only by intermittent glimpses of its strange lineaments. Yet on several occasions, most recently in 2002 for Davis and fellow physicist Masatoshi Koshiba, this dogged pursuit has earned these ghostbusters the physics world's most glittering prize: the Nobel.

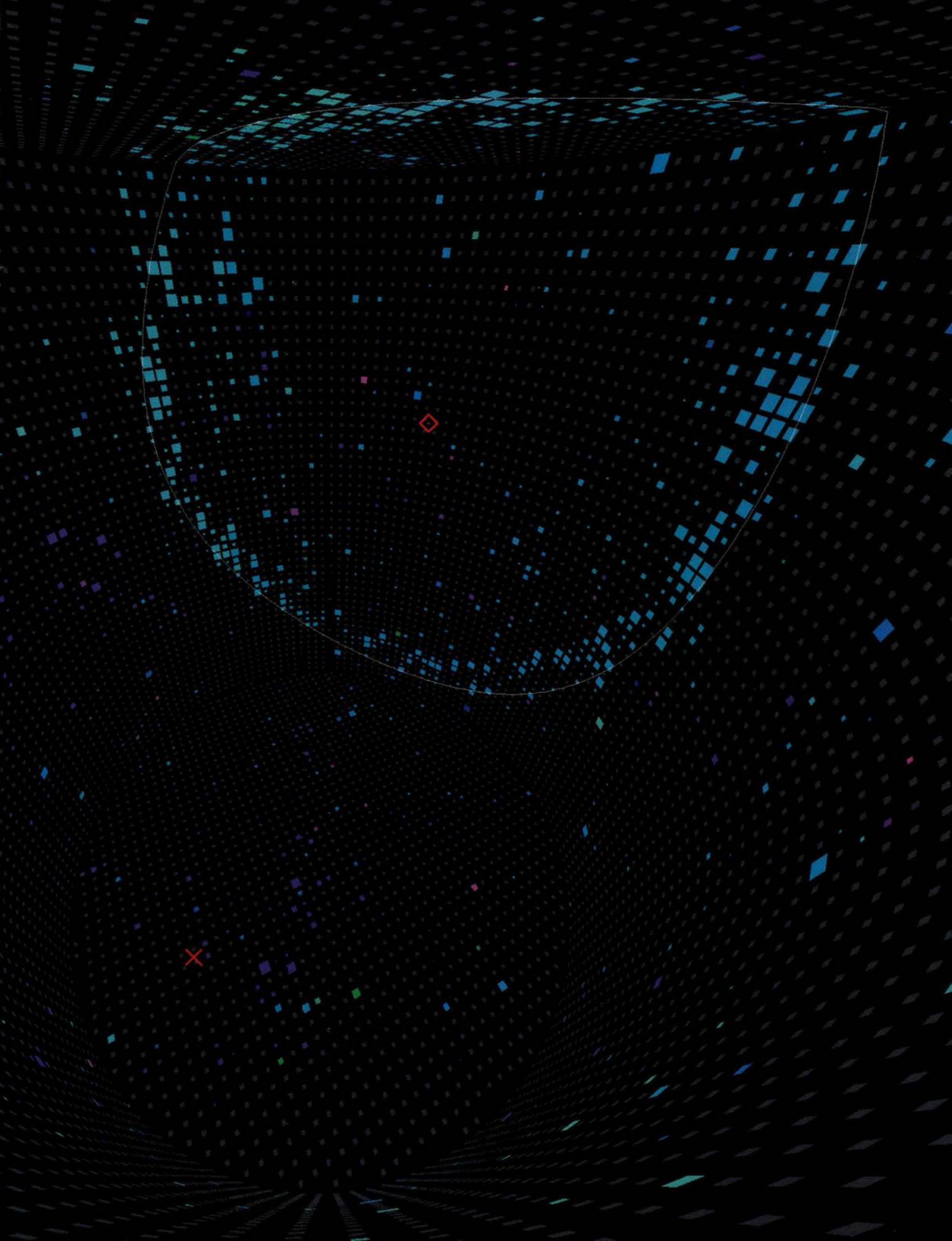
The original "seer" of the neutrino ghost was physicist Wolfgang Pauli. His vision was mathematical. In the late 1920s and 1930s, the early years of quantum physics, Pauli was pondering the problem of beta decay. A radioactive process in the atomic nucleus, beta decay emits an electron as a neutron transforms into a proton. According to the best measurements, something was missing. The sum of the particle momentums before the decay seemed greater than afterward. Such a mismatch violates one of the bedrocks of physics: the principle of energy conservation.



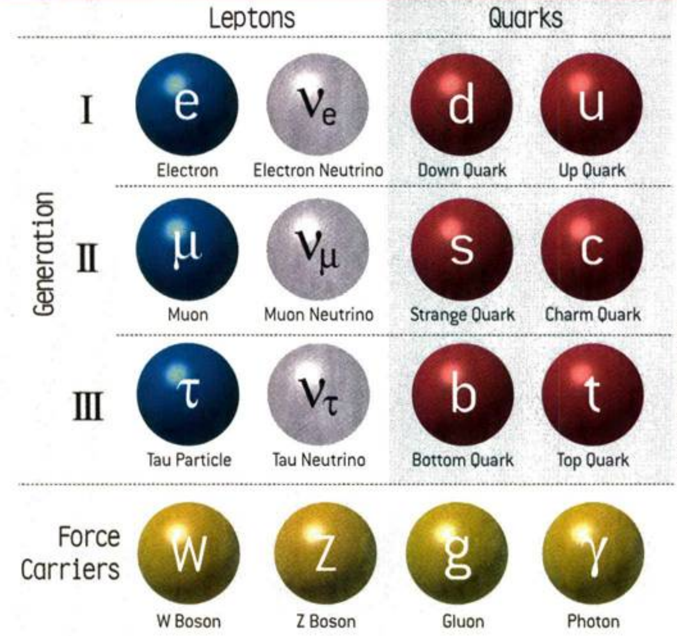
In 1930, while baffled physicists tinkered with theoretical and experimental details, Pauli proposed a more radical — or as he termed it, desperate — remedy. At a time when the known particles numbered just a handful, Pauli proposed an entirely new, unseen, massless, and chargeless particle to carry off the missing energy without a trace. Pauli ruefully apologized to future ghostbusters: "I have done a terrible thing. I have postulated a particle that cannot be detected."

A few years later, the Italian physicist Enrico Fermi took up the task. In 1934, Fermi produced a comprehensive theory of beta decay that described how a weak nuclear force could make atomic nuclei unstable, producing transformations in subatomic particles.

SUPER IN SEVERAL SENSES, the Super Kamiokande detector is a cylinder, 130 feet across and 130 feet high, filled with water and lined with light sensors (above). The wide-angle computer view (right) shows where a muon neutrino passed through the detector. The big light-blue circle shows the flash of Cerenkov light produced by the neutrino, which is traveling faster than the speed of light in water. KAMIOKA OBSERVATORY/UNIVERSITY OF TOKYO/TOMASZ BARSZCZAK



/// A GHOST FAMILY, SLICED AND DICED



ACCORDING TO PHYSICS, the world is made from twelve fundamental particles called fermions: six are quarks and six are leptons. All the hundreds of known particles are combinations of these. In our everyday world, we see only what's termed Generation I fermions. These are electrons and the up and down quarks (which combine to form neutrons and protons).

Fermions in Generations II and III tend to decay into lower generations, and when a heavy lepton (an electron, a muon, or a tau) decays, one of the by-products is a correspondingly-named neutrino.

Matter particles interact by exchanging force particles, collectively called bosons, shown at the bottom of the diagram. At present, the Standard Model can explain how force particles carry the strong, electromagnetic, and weak forces, but it can't explain gravity.

All particles have a particular mass, electric charge, and spin. Each particle also has a corresponding antimatter particle with the same mass and spin but a different electric charge. When a particle meets its antiparticle, the two annihilate in a flash of energy.

A particle changes its spin, or handedness, by interacting with another particle (yet undetected) called the Higgs boson. In the Standard Model, neutrinos and antineutrinos only come in left-handed varieties, so they're massless. But now it looks like neutrinos have mass, so there must be a right-handed neutrino. Somewhere.

ASTRONOMY: ELISABETH ROWAN

The theory depended on Pauli's hypothetical spooky entity, to which Fermi now gave the name *neutrino* (Italian for "little neutral one"). Despite continued skepticism, Fermi's theory gradually gained acceptance because it accurately explained many experimental results.

Meanwhile, other physicists were trying to solve what seemed like a different mystery — what makes the Sun shine. In the late 1930s, another Nobel winner, Hans Bethe, worked out the basic principles of how nuclear reactions power stars. It became apparent that neutrinos held the key to proving his theories. Why? Because like other ghosts wandering the Earth, neutrinos bear a tale of past trauma. As Davis puts it, "Neutrinos tell us what happened in the center of the Sun eight minutes ago."

With Bethe's theory, neutrinos began their starring role in astronomy — and a problematic entanglement in the Standard Model of particle physics. The Standard Model is a theoretical description of the forces and basic building blocks of the universe. Fermi's theory was the first workable exposition of the weak force, one of the four fundamental interactions in the Standard Model. The others are the electromagnetic force, through which electrically charged particles like electrons and protons interact; the strong force, through which "color-charged" particles like quarks interact, for example to make up protons and neutrons; and finally, the gravitational force, by which any two bodies with mass attract each other.

> Your body will capture a neutrino approximately once during your lifetime.

This fourfold model helps explain the neutrino's eerie ability to walk through walls and worlds. Of the four fundamental interactions listed, neutrinos are considered immune to three. Lacking electric charge, neutrinos ignore electromagnetic interactions. Lacking color charge, they are indifferent to the strong interaction. Lacking mass, they are unaffected by the gravitational interaction. So what's left? Only the weak force interactions that produce neutrinos through beta decay.

As their name suggests, weak interactions are rather feeble. They usually do not give neutrinos enough of a kick to produce reactions when they collide with other particles. As a result, neutrinos pass freely through materials built from atoms — paper, people, planets. In fact, neutrinos can pass unhindered through normal matter *several light-years' thick.* No wonder they have earned the nickname "ghost."

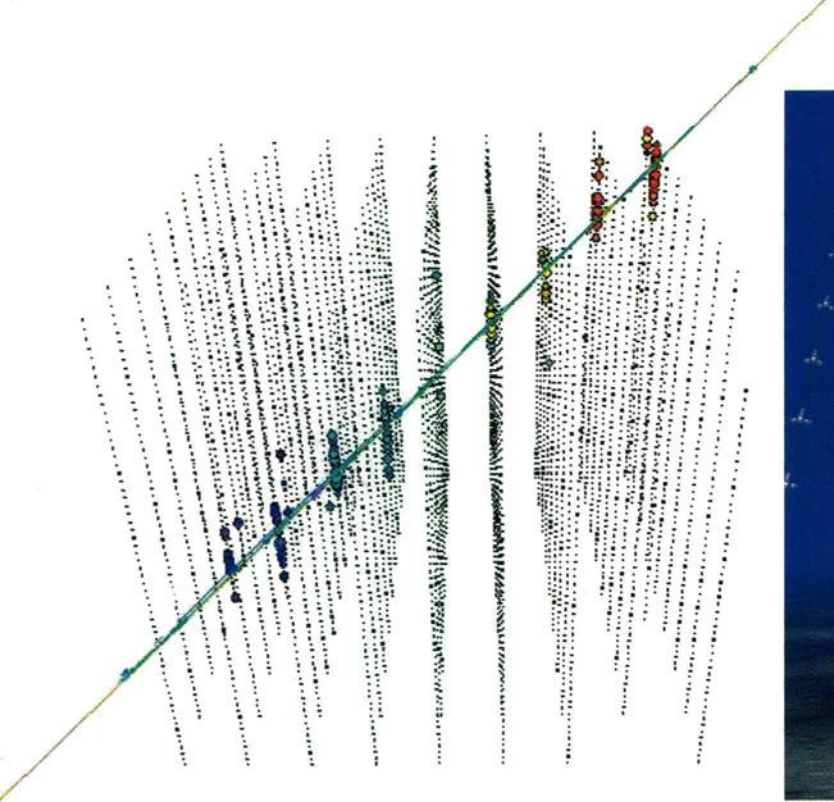
Ghostbusting tools of the trade

At first, no one attempted to prove the neutrino's existence. But in the early 1950s, experimental physicists Fred Reines and Clyde Cowan opened the next chapter in the ghost story — on a dare. Asked why they wanted to detect the neutrino, Reines replied, "Because everyone said you couldn't do it."

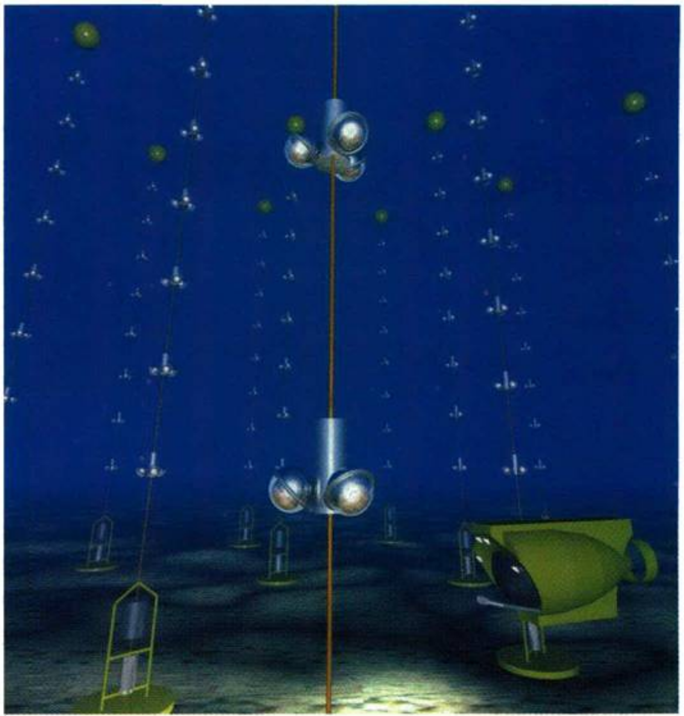
Their experiment, called Project Poltergeist, combined high and low technologies in an original way. Nuclear reactors provided a reliable artificial alternative to natural neutrino production, while state-of-the-art sensors detected particles as brief flashes of light inside a big water-filled tank placed deep within a mine. By 1955, Reines and Cowan announced the first experimental proof for the neutrino, a particle described by Reines as "the most tiny quantity of reality ever imagined by a human being."

Reines and Cowan's original ghostbusting tool kit became almost standard issue for succeeding neutrino-chasers. It's easy to see why. Neutrino detection presents huge experimental

Alison Boyle and Ken Grimes *are science writers based in London.*



ICE FISHING FOR NEUTRINOS — the IceCube neutrino "telescope" at the South Pole will place 4,800 light sensors throughout 1 cubic kilometer of clear ice. This image simulates the track of a muon neutrino. UNIV. OF WISCONSIN



LIKE STRANDS OF HIGH-TECH KELP, the Antares detector array rises from the sea floor off Marseille, France. Precisely timing a neutrino's light flash is the key for tracking a particle's path through the array. F. MONTANET/ANTARES

problems. The rarity of neutrino interactions demands a plentiful source of particles and a large absorption device, or neutrino target. The tiny amounts of energy involved require sensitive measuring devices well protected from Earth's background radiation.

In 1962, Nobel winners Leon Lederman, Melvin Schwartz, and Jack Steinberger built a 10-ton spark chamber, a target made from ninety 1-inch-thick aluminum plates, and a 43-foot-thick, 2,000-ton steel shield built of armor plating from scrapped warships. An artificial source delivered neutrinos in pulses of 10 million particles. The result: The researchers successfully busted a new species of spook — the muon neutrino. Whereas the original neutrino was associated with the electron (and is now called the electron neutrino), the muon neutrino derived its name from another subatomic particle called the muon.

The third neutrino type (or "flavor" in the jargon), the tau, was predicted in 1978 by another Nobel winner, Martin Perl. Superlatively ghostly, the tau neutrino had to wait until 2000 before scientists confirmed its existence. These three neutrinos — electron, muon, and tau — coupled with their three like-named particles, constitute half of the twelve known fundamental building blocks (see "A ghost family" on the opposite page).

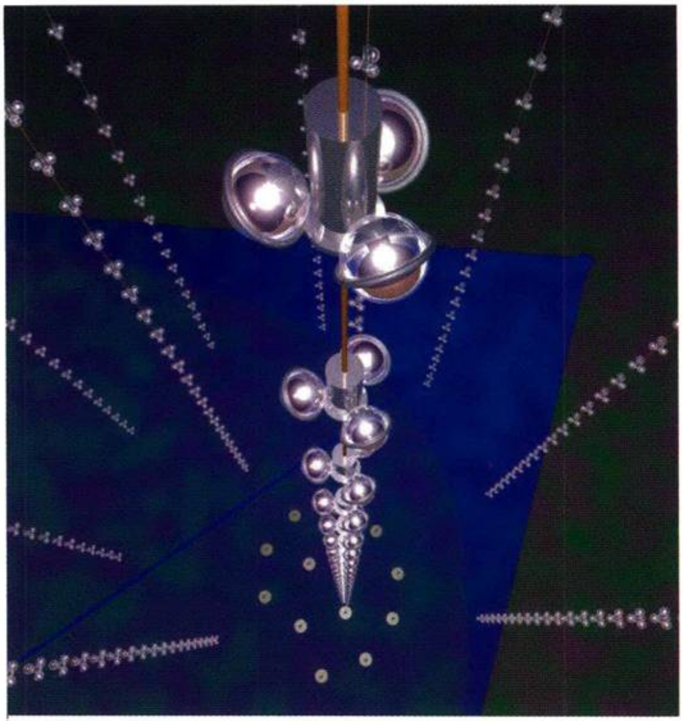
Solar ghosts

If detecting neutrinos was difficult when the detector sat next to a source spewing swarms of them, then what were the chances of busting a natural neutrino originating 93 million miles away in the Sun? Yet capturing a few of them would be the only way for scientists to confirm that the Sun runs on nuclear processes similar to those producing homegrown neutrinos in reactors.

Hans Bethe determined that for stars around the size of the Sun, the major energy source is hydrogen converting into helium. In each cycle, four hydrogen nuclei fuse to form a helium nucleus. This is less massive than the initial constituents and the leftover mass converts to radiation via Einstein's famous formula, $E = mc^2$. As with Pauli's original vision, the numbers must all add up, so other particles come into play to balance the equations. The net by-products of the hydrogen-helium reaction are two positively charged electrons (called positrons) and their ghostly comrades, two electron neutrinos.

Back in the 1940s, Bruno Pontecorvo and Luis Alvarez had suggested a possible method for capturing natural neutrinos. According to their theory, an electron neutrino originating in the Sun should, if it collided with the nucleus of a chlorine atom, produce a radioactive atom of argon. All a would-be ghostbuster needed, then, was the experimental deftness to construct a chlorine-rich target massive enough to catch a natural neutrino. (The odds, however, are ten-quadrillion times smaller than those of capturing the reactor-bred cousin.) The second part of the problem was equally tricky: isolating the resulting one argon atom. This has roughly the same likelihood as locating one particular grain of sand in the Sahara Desert.

No takers to the challenge appeared until the 1970s. Ray Davis, Jr., an experimental physicist with a background in chemistry, built a neutrino detector consisting of a tank holding 100,000 gallons of chlorine-rich dry cleaning solution, equipped with batteries of single-atom argon detectors. To isolate the detectors from other sources of radiation, Davis placed the tank 4,800 feet underground in a gold mine in Homestake, South Dakota. Davis faced not only astronomical odds, but widespread skepticism at a time when, in his own words, "Not everyone would be willing to say that he believed in the existence of the neutrino." Despite such obstacles, Davis managed to extract an average of 17 argon atoms from 10^{30} chlorine atoms every month for a quarter-century, trapping a total of about two thousand electron neutrinos.



A MUON NEUTRINO RACES through the Antares detector, spreading a cone of Cerenkov light behind it, in this simulated view looking down one of the ten vertical strings of light sensors. FRANCOIS MONTANET/ANTARES

Davis's results confirmed that the Sun, in fact, does produce neutrinos and therefore is powered by the thermonuclear fusion of hydrogen into helium. More than this, though, the Nobel citation recognized Davis's visionary role in doing the undoable and establishing a new branch of astrophysics: solar neutrino research. However, his results also produced a new conundrum.

Phantom shapeshifters

Davis detected only about a third as many electron neutrinos as expected. The mismatch between experimental data and theoretical prediction became known as the Solar Neutrino Problem. It implied one of three things: the experiment was wrong, the standard solar model was wrong, or something spooky happened to neutrinos on their journey from the Sun.

In 1987, a Japanese ghostbusting team led by Masatoshi Koshiba, Davis's co-Nobelist, discounted the first of these possibilities. He built a detector named Kamiokande that could register the time of collision events and track the direction of incoming particles. The experiment's results removed any remaining doubt that wild neutrinos originated in the Sun.

Koshiba's experiment also confirmed Davis's discovery — of both solar neutrinos and the Solar Neutrino Problem — when it recorded the same shortfall of predicted particles. As Koshiba put it, "The experiment was right; the solar model was right. It was the neutrinos themselves which were in some way misbehaving."

Koshiba's group then turned to a hypothesis proposed in 1968 by Pontecorvo and Vladimir Gribov. They hypothesized that electron neutrinos originating from the Sun might change flavor (i.e., type) en route. Such oscillations would reduce the flux of electron neutrinos reaching Earth in favor of other types. Both Homestake and Kamiokande were sensitive only to electron neutrinos, so the working theory was that when electron neutrinos mutated into muon or tau neutrinos while traveling to Earth, they would be missed by the detectors — thus the observed shortfall.

In 1996, in pursuit of this theory, Koshiba built the Super Kamiokande detector — "super" in that its 50,000-ton water tank was many times larger than its predecessor and employed 11,000 photomultiplier sensors. The new equipment's increased sensitivity enabled it to detect the muon flavor of neutrino also, and calculations based on the results confirmed that neutrinos could indeed oscillate between electron and muon types.

Cosmos confounded

With neutrinos' stealthy shapeshifting unmasked, Bethe's theories of stellar furnaces were endorsed resoundingly. While it seems that we now understand how stars work, many larger-scale mysteries remain. Neutrinos could provide the solution to some — or true to form, cause even more cosmic confusion.

Flavor oscillation is more than just a curious particle phenomenon. If neutrinos oscillate, it implies they must have mass, contrary to Pauli's prediction. Quantum physics theory says that the probability of a neutrino changing flavor from one type to another depends on the difference in mass between the types. So if neutrinos are changing type, each type must have a different mass, which means those masses can't be zero. And a non-zero neutrino mass raises all kinds of possibilities.

Astronomers have long known that the universe contains more matter than we can see — otherwise galaxies would not have enough mass to hold together. But what makes up this dark matter remains a mystery. Perhaps neutrinos, tiny though they are, could provide a solution. "We now know that neutrinos constitute about as much mass as all the stars one sees in the night sky," says neutrino physicist John Learned. "It could be a lot more. Cosmologists need to take neutrinos into account."

What influence the tiny ghost has on the universe depends on exactly what its mass is. In the early universe, small wrinkles in the fabric of space evolved into the large structures (galaxies and galaxy clusters) that we observe today. Neutrinos, streaming through at nearly the speed of light, helped to iron out these wrinkles. The heavier neutrinos are, the smoother or emptier today's universe should look.

Galaxy-mapping surveys, like the recent Anglo-Australian 2dF study, are helping to pin down neutrinos' masses. By comparing the observed makeup of the universe with theoretical models based on different neutrino masses, the 2dF results suggest that the neutrino mass is very small — less than a billionth of a hydrogen atom — and that neutrinos can therefore account for only about one-fifth of the dark matter content of the universe. Some as-yet-unknown spook species of particle has to be responsible for the rest.

Neutrinos tell us what happened in the center of the Sun eight minutes ago.

But if neutrinos can't account for dark matter, perhaps they can explain why matter exists at all. In the Big Bang, matter and antimatter should have been created in equal amounts. When a particle meets its antiparticle, they annihilate each other in a flash of light, so there should be nothing left in the universe except lots of radiation zinging around. The particles that we refer to as matter today were somehow left over after the annihilations. It's highly convenient for us that there was a matter–antimatter asymmetry — because otherwise we wouldn't exist — but it remains a mystery to be solved nonetheless.

According to Learned, neutrinos may be one of the most promising mechanisms for generating this asymmetry. An ephemeral type of neutrino might decay preferentially into particles rather than antiparticles, if no one minds a bit of rule-breaking. "There could be all sorts of neutrino-like critters," says Learned, "but no matter how complicated the model, there needs to be some hanky-panky somewhere with CP violations."

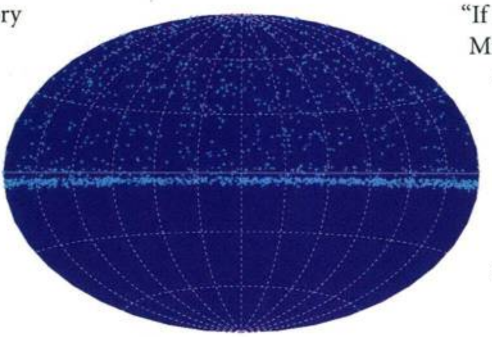
CP, or charge-parity, symmetry is a rule of nature that says the laws of physics would still hold if every particle were replaced by its antiparticle. It also states that the physics of any process and its mirror image are exactly the same. Yet certain particles, including neutrinos, have been observed to disobey this rule.

Their propensity for mischief makes neutrinos into ghosts that refuse to be busted. While scientists finally seem to have shown that neutrinos oscillate, they're now struggling to come up with an addendum to the Standard Model to account for neutrinos having mass. Neutrinos, which theory describes as having a left-handed spin (see "A ghost family" on page 46), also must have a right-handed partner. But how come nobody's spotted it yet?

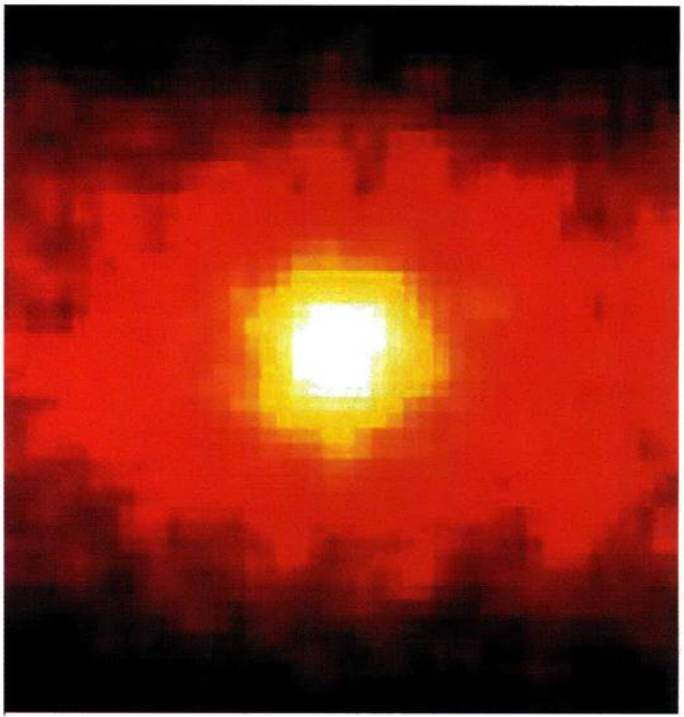
Spooky seesaw

One possibility is that the phantom right-handed neutrino spends much of its time masquerading as a regular neutrino. A leading theory that seeks to combine gravity with the other forces is known as supersymmetry; this theory requires each particle to have a much larger supermassive shadow particle. Each of our three familiar neutrinos could thus spend a tiny fraction of its time as a supermassive right-handed neutrino. Scientists call this the N particle.

If that's not weird enough, an alternative to invoking N particles is even spookier, because it suggests that ordinary neutrinos have a dark doppelgänger that lives in a world outside our own. String Theory, which is currently physicists' best hope for a Theory of Everything, describes a universe that has ten or eleven dimensions, including our familiar three spatial ones. It pictures normal neutrinos and the other Standard Model particles as trapped in the three-dimensional world, while other dimensions are populated by exotic ghost particles. In this view, a right-handed "sterile neutrino" could roam around the higher dimensions undetected by us, making its presence felt only through the influence of gravity.



THE NEUTRINO SKY as seen by the AMANDA II array at the South Pole shows the northern hemisphere with neutrinos (produced in Earth's atmosphere) passing through the ice and solid Earth. AMANDA-II PROJECT



A 500-DAY TIME EXPOSURE of the Sun with the Super Kamiokande detector produced this image of neutrinos coming from nuclear reactions in the solar core. The view spans 90 degrees. R.SVOBODA AND K. GORDAN/LSU

A new neutrino-detection experiment is called MiniBooNE (because it's the first phase of the Booster Neutrino Experiment). MiniBooNE is searching for the dark doppelgänger by seeking evidence that neutrino flavors (types) can oscillate between the muon and electron varieties. The mathematics of such oscillations would favor the existence of a sterile neutrino. An experiment at Los Alamos National Laboratory in 1996 indicated that muon and electron neutrinos did oscillate, but the results have been disputed by other researchers. When complete, MiniBooNE should settle the argument.

"If none of the other evidence changes and if MiniBooNE sees a signal, then the simplest explanation is that there are indeed sterile neutrinos. And that would be really exciting," says project spokesperson Janet Conrad.

Much work remains to be done. The current crop of detectors is sensitive only to higher-energy neutrinos. However, the bulk of the Sun's neutrinos lurk at lower energies, which are harder to work with. To date, ghostbusters have succeeded in studying only about 0.005 percent of the neutrinos the Sun emits. This means only the least elusive ghosts have been busted so far.

Even that, though, is quite a feat, one which ushers Raymond Davis and Masatoshi Koshiba into the ranks of scientists able to utter the immortal words of Dr. Peter Venkman (played by Bill Murray) in the movie *Ghostbusters*:

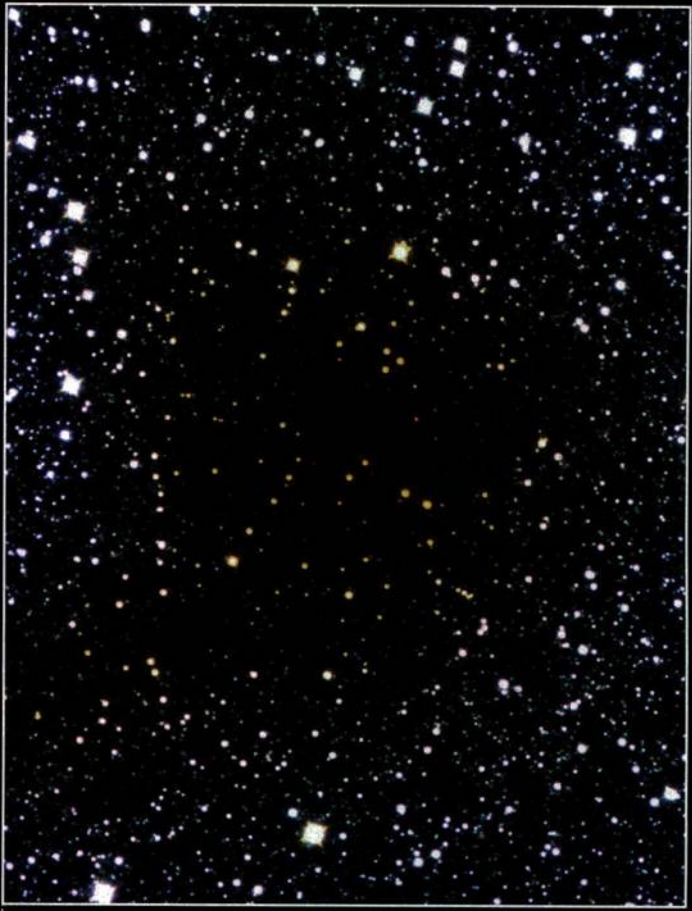
"We came, we saw, we kicked its ass!"

To learn more about how abandoned mines and Antarctic ice help astronomers find neutrinos, visit www.astronomy.com/toc

The black cloud

A frigid blob of gas and dust hovers nearby, possibly foreshadowing a stellar birth.

/// BY KEN CROSWELL



THE IMPENETRABLE BLACK SHROUD that is Barnard 68 in visible light (facing page) becomes transparent in this infrared image taken by the New Technology Telescope in Chile. Because the color of background starlight traces the density of dust and gas in the globule, such images revealed that Barnard 68 is densest at its core. This density profile helps illuminate how molecular clouds form stars. EUROPEAN SOUTHERN OBSERVATORY

STARS ARE HOT AND BRIGHT, YET THEY CAN OWE THEIR EXISTENCE TO THE cold and dark — frigid black clouds of gas and dust that float through interstellar space. The perfect example resides in southern Ophiuchus, east of Antares, where a black cloud named Barnard 68 blocks the light of thousands of stars that throng the Milky Way's central bulge.

Barnard 68 lies 300 to 400 light-years from Earth, so close that not a single foreground star mars its exquisite blackness. It measures 5 light-months across, corresponding to a radius 12,000 times greater than the Earth-Sun distance. Place the solar system at its center and it would engulf all the planets as well as the inner part of the Oort cloud of comets. It also would doom optical astronomy, blacking out every visible object beyond the solar system.

Cataloged by American astronomer Edward Emerson Barnard in 1919, the cloud is now classified as a Bok globule. In 1947, Harvard astronomers Bart Bok and Edith Reilly suggested that such a globule could collapse to form a star. Their idea later fell out of favor, but during the 1980s and 1990s, observations at infrared wavelengths — which penetrate the dust — confirmed that many Bok globules actually do nurse newborn stars.

Barnard 68, though, is still starless, giving astronomers the chance to study the first stage of star birth. The cloud has roughly the same mass as the Sun and consists mostly of two transparent gases — molecular hydrogen and atomic helium. But dust grains composed of heavier elements pepper the gas, darkening the cloud. And Barnard 68 *is* dark. Shoot a trillion photons of yellow light through its center and just one would reach the other side. If the Sun shone at its edge, an observer at the opposite edge would need a powerful telescope to see it as a dim star of 25th magnitude.

The cloud is as cold as it is dark: The temperature throughout is a mere 10 degrees Celsius above absolute zero, or –440° Fahrenheit, 40° F colder than Pluto. It's so cold that most of the carbon monoxide and nitrogen gases have frozen onto the cloud's dust grains. The extreme cold is vital to the black cloud's starry future. To create a star, the cloud must collapse. However, the cloud's own heat threatens the collapse by exerting an outward pressure that counteracts gravity's inward pull. Because there isn't much heat, though, there isn't much outward pressure. If the collapse occurs, gravity will heat the infalling material, making it glow. (In the same way, gravity causes water to fall over a dam and generate energy.)

At January's meeting of the American Astronomical Society in Seattle, Charles Lada of the Harvard-Smithsonian Center for Astrophysics reported that Doppler shifts show the cloud's central parts to be moving inward while its outer layers are moving outward. This behavior suggests to him that Barnard 68 is vibrating — or, in his words, "jiggling like Jell-O" — once every 250,000 years. If so, it's the first Bok globule found to quiver. Or perhaps the cloud's collapse has begun already.

Barnard 68's fate is unclear. It may give birth to a new star, or it may dissipate into space. If all goes well, however, the cloud's gravity, perhaps augmented by the shock of a nearby supernova explosion, will cause the gas and dust to cascade toward the cloud's center. And from the cold shall come warmth, and from the dark shall come light, as another new star takes its place in the Milky Way.

Ken Croswell *is an astronomer in Berkeley, California, and author of the new book* Magnificent Mars. *He thanks the late Sir Fred Hoyle for supplying this article's title in his 1957 novel* The Black Cloud.

If you would like to see this black cloud for yourself, check out its finder chart at www.astronomy.com/toc

JOÃO ALVES (ESO), CHARLES LADA (CfA), and ELIZABETH LADA (UNIVERSITY OF FLORIDA)

The rise and fall of TYCHO BRAHE

This 16th-century Danish astronomer braved the slings and arrows of outrageous fortune and made thousands of observations that helped ignite the Scientific Revolution. /// BY DAN FALK

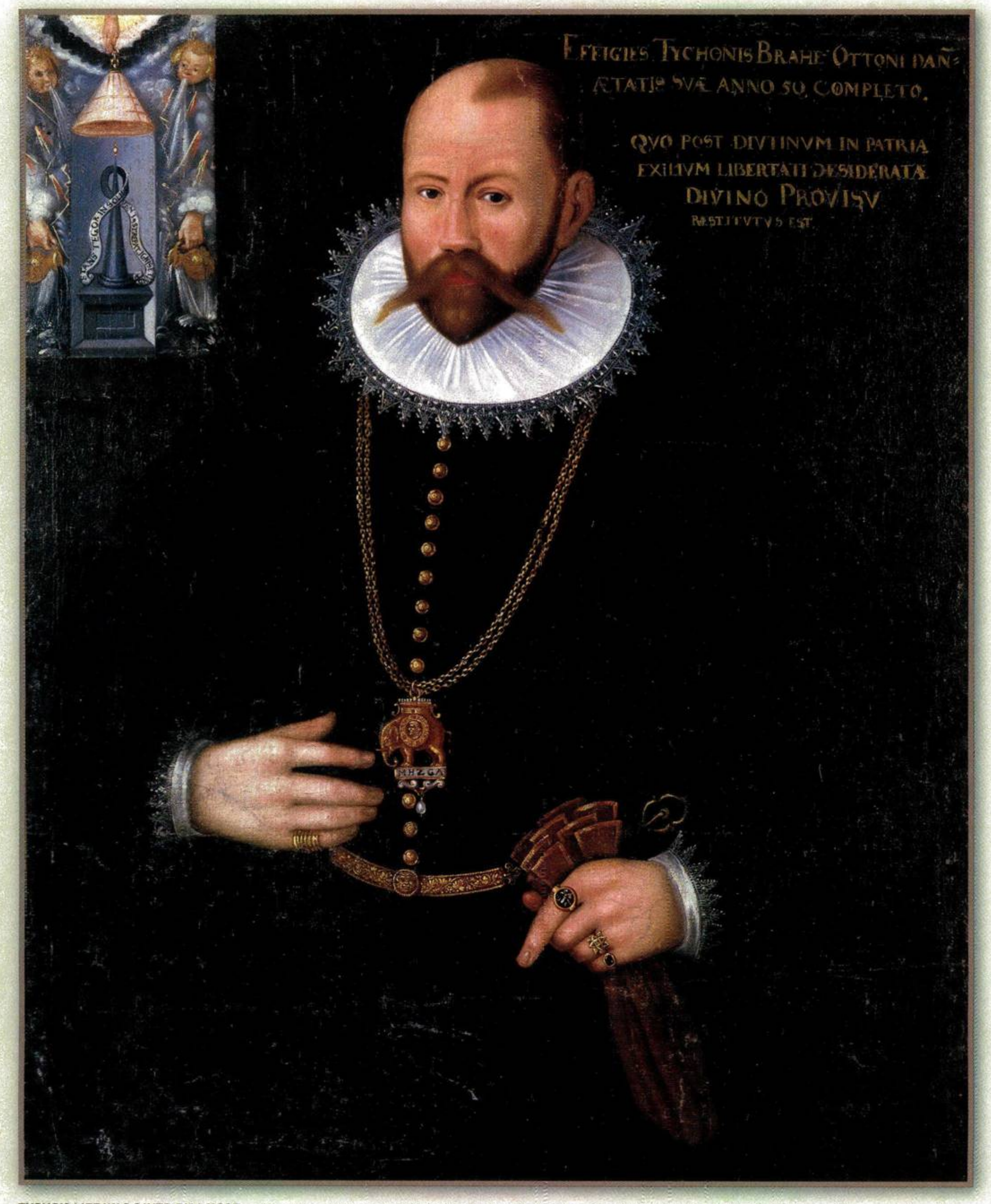
As astronomy emerged from the shadows of antiquity in the 1500s, the most advanced observatory in the world wasn't in Athens, Rome, Alexandria, or even Samarkand. It was on a tiny Baltic island ruled by a feudal lord. There, Tycho Brahe studied the heavens, measured star and planet positions, and created an observational legacy that built modern astronomy.

Remarkably, this meticulous observer lived before the age of the telescope. His painstaking studies of planets, the Sun, and nearly eight hundred stars paved the way for Kepler, Galileo, and Newton, whose discoveries shattered the medieval European worldview and replaced it with a new perspective rooted in science.

Tycho's own exploits rival his scientific reputation. He lost part of his nose in a duel with his third cousin when he was 20, subsequently attaching false noses made of silver and gold or copper (for everyday wear). After years of neglecting his nobleman's duties, he became *persona non grata* in his homeland and was sent into exile, seeking refuge in Prague, where he took the young mathematician Johannes Kepler under his wing. It was this association with Kepler that has both hurt his reputation — unlike Kepler, Tycho was never able to discern the mathematical order that lay hidden in his own observations — and made him an enduring figure.

But no one can question his observational prowess. "I think Tycho Brahe has been portrayed as an egotistic eccentric who was making all these observations just to hand them over to Kepler, the 'architect' who knew what to do with them," says Owen Gingerich, an astronomer and historian of science at Harvard University. "But when you realize the overwhelming nature of getting so many observations — of all the planets, and of the stars, Sun, and Moon — this was an accomplishment that was unparalleled. You have to place Tycho Brahe very high in the pantheon of astronomical greats."

Tycho was born in the Danish province of Skaane (today part of southern Sweden) in 1546 — three years after the publication of Copernicus's book on the structure of the solar system, *On the Revolution of Heavenly Spheres*, but still a half-century before Galileo would aim a telescope toward the heavens. Tycho was born into a powerful noble family who assumed he eventually would serve the king as a soldier or an administrator. He enrolled as a law student at the University of Copenhagen but soon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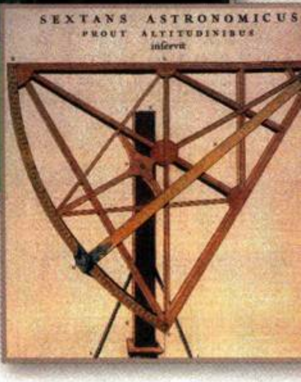
TYCHO'S LIFE WAS SAVED BY A NOSE — his own — during a duel with his cousin when Tycho was 20. He might have died had his cousin's sword pierced more than his nose and forehead; he wore metal prostheses thereafter. LSH PHOTO/SKOKLOSTER CASTLE COLLECTION



NOBILITY WAS TYCHO'S BIRTHRIGHT, having been born into an aristocratic family that occupied Knutstorp Castle [above]. Tycho's instruments included an armillary sphere such as this replica [left] and sextant [right] — but no telescopes; they had not been invented yet. LEFT AND ABOVE: DAN FALK; RIGHT: R. BURNHAM/AMERICAN GEOGRAPHICAL SOCIETY LIBRARY, UNIVERSITY OF WISCONSIN–MILWAUKEE LIBRARIES

witnessed a series of events in the sky that sparked a lifelong fascination with astronomy.

The first was the solar eclipse of 1560. Tycho, a wide-eyed teenager, was amazed that astronomers were able to predict such events months or even years in advance. Later, while studying in Germany, he saw a close conjunction of Jupiter and Saturn — an eye-catching planetary gathering that occurs once about every 20 years. But Tycho noticed that the published tables predicting the event — whether based on Ptolemy's ancient system, or the newer Copernican model — were grossly inaccurate. The time given for the closest approach of the two planets was off by several days. Suddenly, Tycho knew his true calling: He would devote the rest of his life to making the most accurate observations possible of the heavenly bodies.

> Tycho had given the world a new kind of institution of learning – a scientific laboratory where people could devote their lives to the study of nature, never wanting for expertise, equipment, or funds.

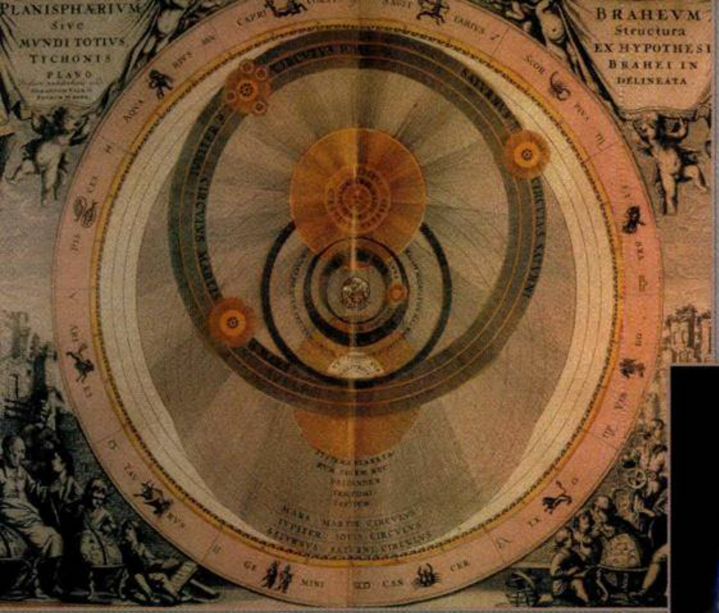
An even more spectacular event lit up the skies in November 1572, when a bright "new star" appeared in the constellation Cassiopeia. Today we would call it a supernova, the explosion that takes place when a massive star exhausts its nuclear fuel supply. Tycho described the event in his book, *De Stella Nova* ("On the New Star"): "I noticed that a new and unusual star, surpassing all the other stars in brilliancy, was shining almost directly above my head. And since I had almost from boyhood known all the stars of the heavens perfectly . . . it was quite evident to me that there had never before been any star at that place in the sky, even the smallest, to say nothing of a star so conspicuously bright as this."

The standard cosmology of the day — founded on biblical scripture and the ancient texts of Ptolemy and Aristotle — forbade any changes in the starry heavens. Any new objects, like comets or Tycho's new star, were assumed to be atmospheric phenomena. But if that were the case with his new star, Tycho reasoned, the star would display parallax — that is, its position relative to the background stars would change over the course of the night, as Earth rotated. But careful observation of his star showed no discernable parallax.

"I conclude," he wrote, "that this star is not some kind of comet or fiery meteor . . . but that it is a star shining in the firmament itself — one that has never previously been seen before our time, in any age since the beginning of the world."

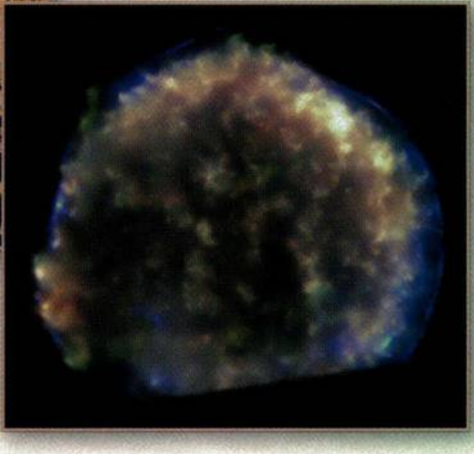
Tycho's observation dealt a shattering blow to the established cosmological order — and almost overnight, it made Tycho the leading astronomer of his generation. Tycho's report on the new star also caught the attention of the Danish king, Frederick II, who resolved to keep the illustrious Tycho close to home, where his work would glorify crown and country.

In 1576, the king made Tycho a remarkably generous offer: an island of his own in the channel between present-day Denmark and Sweden, where Tycho could pursue his dream of mapping the cosmos. "If you want to settle down on the island," Tycho reported of the king's proposal to him, "I would be glad to give it to you as a fief. There you can live peacefully and carry out the studies that interest you, without anyone disturbing you. . . . I will sail over to the island from time to time and see your work in astronomy and chemistry, and gladly support your investigations . . ." It was an offer Tycho couldn't refuse.



TYCHO'S SOLAR SYSTEM was a compromise between the models of Ptolemy and Copernicus. In Tycho's model, the other planets revolved around the Sun, but the Sun revolved around Earth. Kepler, Tycho's student, later used Tycho's myriad observations to devise laws that supported a Sun-centered solar system. R. BURNHAM/AMERICAN GEOGRAPHICAL SOCIETY LIBRARY, UNIVERSITY OF WISCONSIN–MILWAUKEE LIBRARIES

TYCHO'S "NEW STAR" OF 1572 challenged prevailing theories that the heavens were unchanging and catapulted Tycho to fame and fortune. Recent studies suggest he observed a white dwarf exploding as a type Ia supernova. In this Chandra X-ray Observatory image of its remnant, red, green, and blue represent low, medium, and high x-ray energies, respectively. NASA/CXC/SAO



TYCHO'S LAST HOME was at No. 1 Novy Svet in Prague. Ironically, the astronomer exiled for his impudence died trying to be polite — by holding his urine too long at a dinner party in October 1601. DAN FALK

Tycho soon transformed the 3-mile-long island, called Ven, into Europe's foremost center of astronomical learning. (The island's pronunciation, somewhere between "vane" and "vee-yen," depends on which side of the channel you live. To further complicate matters, the old Danish spelling, Hven, often is used in biographies of Tycho.) In just a few months, Tycho and his assistants — he called them his *familia* — were observing the Sun, the Moon, planets, comets, and stars, inventing new tools for astronomy and map making, and using their own printing press to share their findings with the world. Learned young men from across the continent descended on Tycho's laboratory, known as Uraniborg ("Heavenly Castle"), eager for a chance to work with the great observer.

The castle, which sadly no longer stands, was built in the grand style of the early Renaissance, with turrets, buttresses, and stone archways. As impressive as it must have been, however, Tycho found the castle too small and unsteady — his instruments must have shaken whenever winds were strong — so he built a second observatory across the road. Known as Stjerneborg ("Castle of the Stars"), its subterranean foundation provided rock-steady support for Tycho's instruments.

The best known of these is the great mural quadrant. With a radius of more than 6 feet, the mural — which no longer exists — occupied an entire wall oriented on a precise north-south line. The altitude of celestial objects that passed into view in the wall's plane could be measured to a resolution of 10" — about 0.5 percent of the Full Moon's apparent size. He also employed large sextants of wood or steel, several quadrants, and at least one armillary sphere — an ancient, intricate device used to model the heavenly spheres on which the stars and planets were thought to revolve.

With Uraniborg's construction, Tycho had given the world a new kind of institution of learning — a scientific laboratory where men could devote their lives to the study of nature, never wanting for expertise, equipment, or funds. Historians estimate Uraniborg received between 1 and 1.5 percent of the Danish national budget. "This was the first true research establishment in modern times," says Gingerich. "There was nothing like it."

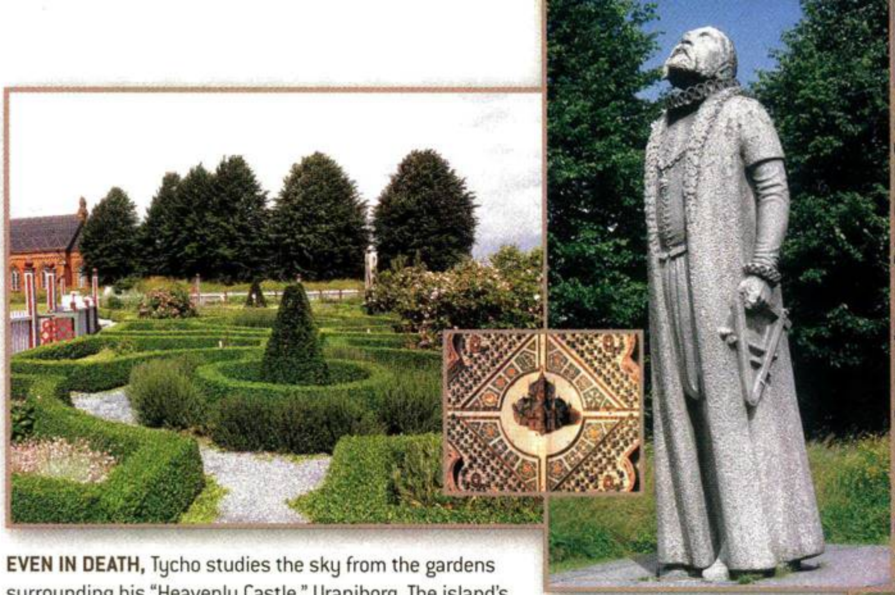
Yet Uraniborg was more than just a place of scholarly learning. With its grand architecture, orchards, fish ponds, and aviary, it was also a place of beauty — a place of inspiration. Historian John Robert Christianson describes the scene in his recent book, *On Tycho's Island: Tycho Brahe and His Assistants, 1570–1601*: "This was truly a microcosm, offering beauty, harmony, health, and delight to all the senses, for the abundance of the world was here: If ever it were possible to know the Creator through his Creation, this was the place."

By today's standards, Tycho's arrangement on Ven sounds like a scientist's dream. Yet Tycho faced personal and political difficulties. His common-law marriage to a peasant girl, Kirsten Jørgensdatter, was never given the blessing of the Church or the Danish court. Later, the engagement of Tycho's daughter to a worldly young doctor ended disastrously, with the groom-to-be becoming one of Tycho's most formidable enemies. Other noblemen, meanwhile, were resentful of Tycho's influence and independence.

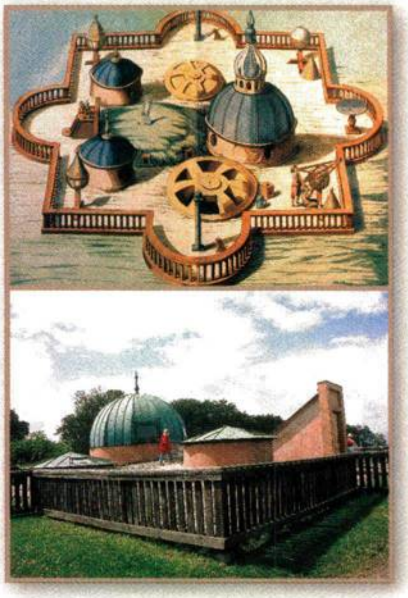
The last traces of his good standing in Denmark dissolved with the death of Frederick II. The new king, Christian IV, sought to concentrate power in Copenhagen and questioned the expense of Tycho's operations. For his part, Tycho was blatantly remiss in his nobleman's duties. One of his neglected responsibilities was the maintenance of the cathedral in Roskilde, about 25 miles west of Copenhagen; its leaky roof threatened to mar the tombs of the king's father and grandfather. Neglecting the royal chapel was, to use the phrase in its most literal sense, politically incorrect.

The island of Dr. Tycho

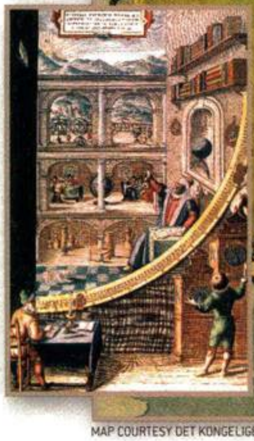
Tycho's discovery of a "new" star in 1572 brought him fame, fortune, and his own island. "If you want to settle down on the island, I would be glad to give it to you as a fief," King Frederick II told Tycho. "There you can live peacefully and carry out the studies that interest you, without anyone disturbing you." Anyone, that is, except for the king's successor, Christian IV, who sent Tycho and his assistants packing after twenty-one years on Ven.



EVEN IN DEATH, Tycho studies the sky from the gardens surrounding his "Heavenly Castle," Uraniborg. The island's centerpiece, Uraniborg originally was used for astronomy, but Tycho wanted a steadier structure for his observations, so he built the Stjerneborg observatory across the road.
LEFT: DAN FALK; INSET: R. BURNHAM/AMERICAN GEOGRAPHICAL SOCIETY LIBRARY, UNIVERSITY OF WISCONSIN–MILWAUKEE LIBRARIES; RIGHT: DAN FALK



STJERNEBORG (left) was built in the 1580s with a subterranean foundation and has been partially reconstructed today (below).
LEFT: R. BURNHAM/AMERICAN GEOGRAPHICAL SOCIETY LIBRARY, UNIVERSITY OF WISCONSIN–MILWAUKEE LIBRARIES; BELOW: DAN FALK



TYCHO'S MURAL QUADRANT, (right) completed in 1582, had a radius of more than 6 feet and occupied an entire wall in the Uraniborg mansion. Tycho used the tool to calculate the position of celestial objects to within 10". This engraving, commissioned by Tycho, shows Tycho making an observation to the right of the quadrant's arc, which encloses a mural of Tycho and his assistants at work.
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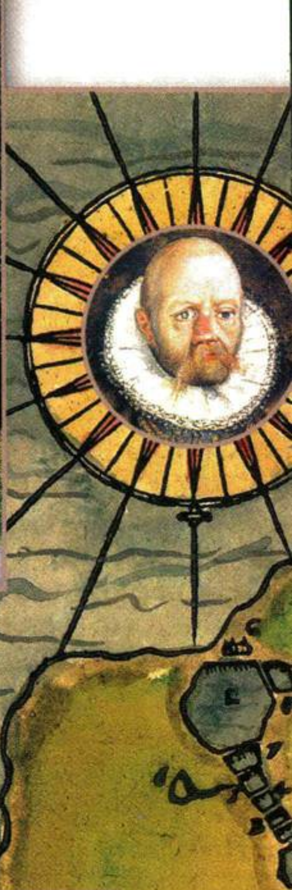

MAP COURTESY DET KONGELIGE BIBLIOTEK, COPENHAGEN;

Ultimately, the great scientist was forced to leave Denmark. In 1599, Tycho accepted a position in Prague under the patronage of Emperor Rudolf II. By then, his reputation as Europe's foremost astronomer was secure. "Tycho came to Prague as a leading person in his field," says Pedr Hadrava, an astrophysicist with the Czech Academy of Sciences. "His position in the court and his salary confirm that he was highly appreciated by the emperor."

Although his most productive years were now behind him, Tycho's mind was still very much caught up in matters of astronomy. He proposed a new model of the solar system — a compromise between those of Ptolemy and Copernicus. In Tycho's model, the other planets revolved around the Sun, but the Sun and the Moon still revolved around Earth. The "common sense" stability of Earth, the absence of stellar parallax (it would be detected only centuries later), and the long-standing prohibition against earthly motion made it impossible for Tycho to embrace Copernicus's Sun-centered system.

But Tycho's most important role in Prague was as a mentor to his young colleague, Johannes Kepler, who would inherit the innumerable volumes of astronomical data gathered on Ven. Today, a dignified bronze sculpture on a hilltop overlooking Prague Castle and the medieval city below shows the two men standing side by side. Not far away, on a narrow cobbled street, a plaque at No. 1 Novy Svet (New World Street) marks the house where Tycho lived during the final years of his life.

In October 1601, a festive dinner party ended in tragedy for Tycho. He had to go to the bathroom, but rather than excuse himself from the table before his host, he held it in. Kepler, writing on the final page of Tycho's log book, described what happened: "Holding his urine longer than he was accustomed to doing, Brahe remained seated. Although he drank a bit overgenerously and felt pressure on his bladder, he had less concern for the

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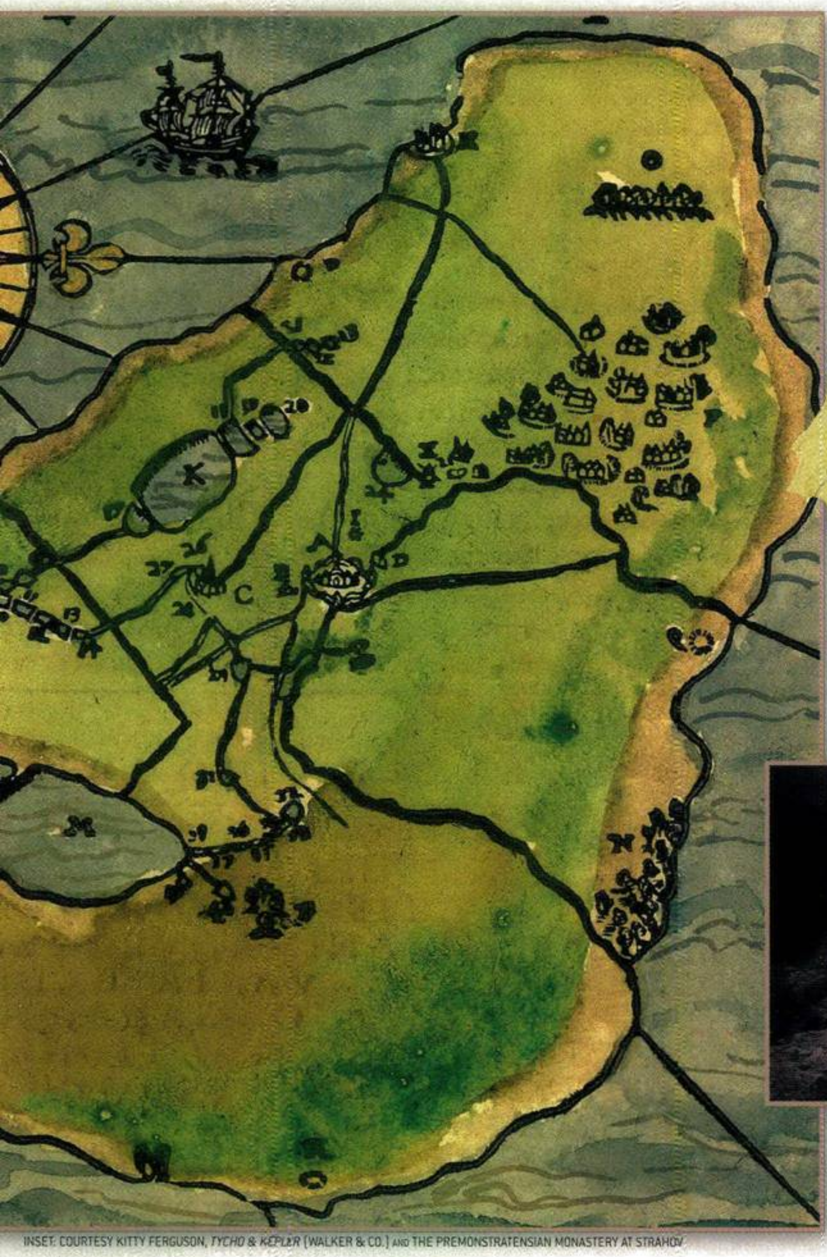
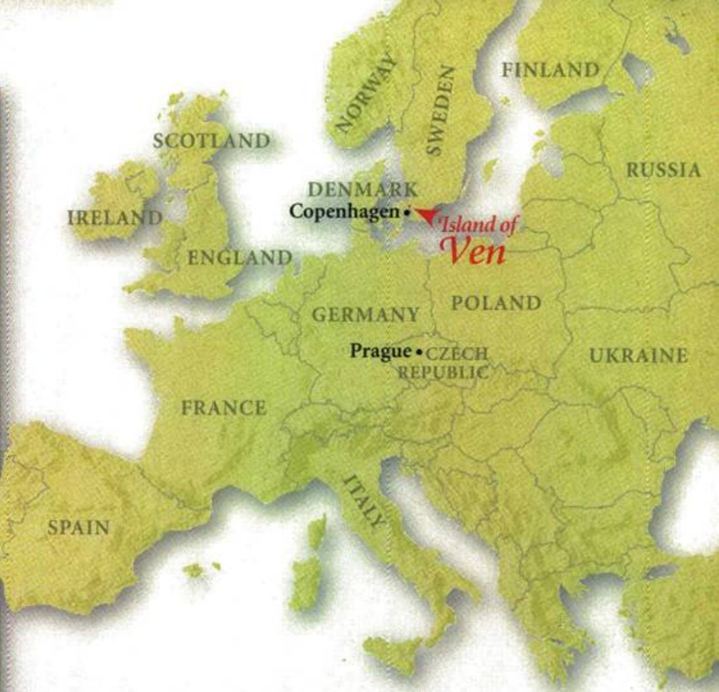
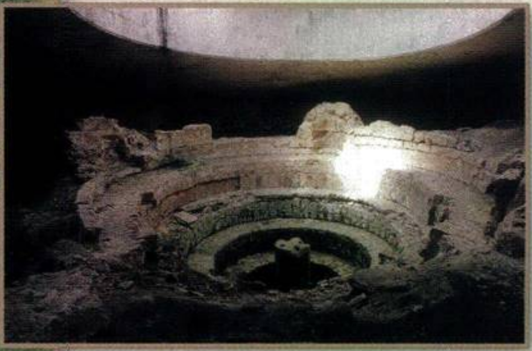
Dan Falk *is a science writer and broadcaster based in Toronto. His first book,* Universe on a T-Shirt: The Quest for the Theory of Everything, *will be published next month.*



INSET: COURTESY KITTY FERGUSON, *TYCHO & KEPLER* (WALKER & CO.) AND THE PREMONSTRATENSIAN MONASTERY AT STRAHOV



TYCHO'S OWN THREE-MILE ISLAND, Ven, lies in a narrow strait between Denmark and Sweden. Perhaps 1.5 percent of the Danish national budget went to support Tycho's research on Ven. ROEN KELLY



RUINS OF THE FOUNDATION OF STJERNEBORG, or Castle of the Stars, show a central pier on which one of Tycho's instruments would have been mounted. DAN FALK

DENMARK'S KING CHRISTIAN IV (below) forced Tycho out of the country after the astronomer neglected to maintain a royal chapel housing tombs of the king's ancestors. PORTRAIT BY PIETER ISAACSZ, COURTESY DET NATIONALHISTORISKE MUSEUM PA FREDERIKSBORG, HILLERØD

state of his health than for etiquette." By the time the party was over, the damage had been done. Tycho, who was probably already suffering from prostate problems, died eleven days later, saying repeatedly on his deathbed, according to Kepler, "Let me not seem to have lived in vain." Tycho is buried in a tomb in the Church of Our Lady before Tyn, on Prague's Old Town Square. An ornate red marble effigy of the great scientist stands above the tomb.

Tycho Brahe never became a household name like Isaac Newton nor is his name linked to any one great discovery like Albert Einstein and relativity. But in hindsight, Tycho was a key figure in the history of astronomy, a man who advanced not only the science of his day but also how science was practiced. If it weren't for Tycho's careful observations, Kepler never could have developed his laws of planetary motion, which led Newton to formulate his law of universal gravitation. Without Tycho, Renaissance astronomy may have limped along for generations; instead, it saw the contemporary view of the cosmos rewritten in the span of just a few decades.

For Owen Gingerich, the sheer magnitude of Tycho's work became apparent during a visit to a Paris bookshop. An obscure volume, published in the mid-1600s, attempted to list all of the observations of the Sun, the Moon, and planets compiled throughout history up to that time. "What's fantastic about the volume," explains Gingerich, "is that the pre-Tychonic observations occupy about ninety pages, and those in the decades after Tycho lived occupy another fifty. The Tychonic observations occupy nine hundred pages." Without Tycho, the hefty tome would have been a mere novella. "The contribution, the sheer bulk of the observations that Tycho Brahe made, is staggering."

Tycho most certainly did not live in vain. ■

To learn more about Tycho's life and the instruments he used, visit www.astronomy.com/toc

DECEMBER 03

The comet with the shortest known period delivers a fine opening act before Saturn rises in the late evening.

The Ringed Planet beats all

Thanks to a series of fortunate coincidences, three fine comets will grace our skies during the next six months. Poised above the glow of evening twilight in the west, Comet 2P/Encke sprouts a small tail that points upward, away from the Sun. Your best views will come under dark skies, but binoculars should reveal this fuzzy object even from the suburbs. The comet gets swallowed by dusk around December 11, so don't let any clear evening pass you by.

As winter progresses, Comet C/2002 T7 (LINEAR) will brighten in the evening sky. Unfortunately, it will disappear for northern observers just before it rises on May mornings as a white flame visible to the naked eye. Comet C/2001 Q4 (NEAT), however, should be thrilling us in spring, echoing the visit from Hale-Bopp just a few years ago.

SATURN REACHES ITS PEAK at opposition on New Year's Eve, when it appears biggest and brightest. ED GRAFTON

Arguably the most beautiful sight in the night sky, Saturn surely will dominate telescope time as midnight approaches. If you observed Saturn earlier this year, you'll notice that its rings have started to close up. In six more years, they will appear edge-on.

On December 31, the Ringed Planet reaches opposition (when it lies opposite the Sun in our sky). At opposition, a planet remains visible all night, rising around sunset and setting near sunrise. Resist the temptation to point your telescope at Saturn as it pokes above the northeastern horizon. You have to look through more of Earth's turbulent atmosphere near the horizon, and it will make a mess of the Ringed Planet's fine face. While you wait for Saturn to rise higher in the sky, have a look at Mercury, Venus, Mars, and the Moon.

Venus is the blazing beacon that appears in the west as dusk settles in. Telescopically, its small, gibbous shape will be difficult to make out in the unsteady evening air. Enjoy the binocular view instead, and search for the starlike, yellowish speck of the planet Mercury to its lower right, about one field of view away. The innermost planet keeps this same approximate distance for the first half of December before slipping back into the bright horizon glow.

Unfortunately, Mars will disappoint most observers. Its apparent size shrinks below 10" this month, presenting a challenge to even the most experienced observers hoping to identify its surface and atmospheric features.

The good news about this year's Geminid meteor shower is that it peaks on a Saturday night, December 13/14. As the year's second best display, it proves a reliable performer, producing a "shooting star" every minute or so. The bad news: The Moon will be prominent and located high in the sky for much of the night, significantly reducing the meteor count from its typical maximum. Don't let this discourage you, however. A fair number of Geminids leave trains — glowing trails of ionized gas left behind by some brighter meteors. The trains result when larger pieces of interplanetary dust burn up in Earth's upper atmosphere.

Also keep an eye out for the Ursid meteor shower at New Moon on the night of December 22. This minor shower typically reaches 5 to 10 meteors per hour, but it has been known to have outbursts that can reach 100 or more.

The Moon is always worth watching. Features such as the Straight Wall cast shadows that evolve in a few hours and disappear in a matter of days. The Straight Wall emerges into sunlight on the opening evening of December and once again on New Year's Eve.

After scooting below Mars on the 1st, the Moon slips above Saturn on the 10th and vaults over Jupiter on the morning of the 16th. Take a closer look at mid-morning on the 16th: You can use the Moon to guide your eye to Jupiter during broad daylight.

The Moon's continued wandering bestows a heavenly gift to observers on the 25th. Look for a resplendent crescent Moon next to the evening star, Venus, as twilight deepens.

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NexStar 9.25 GPS**

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Introducing the NexStar 9.25 GPS.

The Celestron 9.25" optical tube was already a favorite among astrophotographers and discerning visual observers, but now with the **carbon fiber tube** and the **NexStar GPS mount**, it is a formidable addition to the NexStar GPS family. The 9.25 was **specifically designed for visual infinity focus when using 2" eyepieces** and has an **optimized baffle system** to benefit astrophotography by minimizing vignetting at the edge of the field of view. Its **longer primary focal length** and **lower magnification secondary mirror** contribute to a flatter field of view at the focal plane and helps to further reduce optical aberrations. ***This feature-packed model comes standard with a carbon fiber tube and Celestron's renowned StarBright® multi-coatings.*** The NexStar 9.25 GPS is compatible with the complete line of Celestron photographic and visual accessories.

What makes the NexStar 9.25 GPS great for astrophotography?

- **Longer focal length primary and lower magnification secondary** — Contributes to a flatter focal plane with less coma and off-axis astigmatism.
- **Baffle design** — Optimized for astrophotography. Minimizes vignetting at the edge of the field of view. This reduces light drop off at the corners of your film plane.

NexStar GPS. Quality that's designed in — not added on.

NexStar GPS Standard Software Features:

- **GPS Align** – Press the Align button and the telescope will automatically begin its alignment sequence.
- **Database** – 40,000 + objects in database.
- **Magnetic North Compass Compensation** – Magnetic north and true north are not the same; magnetic north varies depending upon your position on the earth. The NexStar allows you to compensate for the variation. This improves pointing during the automated GPS alignment process.
- **Quick Align** – Gets the telescope tracking the sky without actually aligning it to two stars. Useful for tracking planets or solar observing.
- **EQ Auto Align** – The telescope will automatically pick and slew to your alignment stars even in equatorial mode.
- **Polar Alignment Routine** –The NexStar has a polar alignment algorithm making polar alignment easy and accurate for equatorial use.
- **User-defined Filter Limits** – When filter limit is set, the hand control will only display objects above the horizon or as set by the user.
- **User defined Slew Limits** – Set the maximum and minimum slew limits on the altitude axis.

Quality Components:

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
- 32-pitch, 5.625" pitch diameter, 180-tooth Bronze gear.
- Stainless steel worm shaft.
- Precision annealed Pyrex primary and secondary mirrors.
- **Carbon Fiber Tube** –1/4 the thermal expansion of aluminum; creates a more stable focus. The tube is four times more resistant to temperature changes than aluminum tubes; minimizes your need to re-focus.

Intelligent Design:

- Built-in 16-channel GPS receiver, magnetic compass and internal altitude switch work together to fully automate the alignment process.
- **Internal Slip Ring** – Eliminates power cable wrapping.
- **Auxiliary ports are located on the rotating base** – Auxiliary port rotates with the telescope; vastly improves cable management.
- **Ergonomic design** - Carrying handles strategically placed for improved lifting power and stability; hand control integrated in fork arm for ease of use whether on the scope or in your hand.
- **Optical Tube Assembly Mounting Rails** – An outer rail on each side of the optical tube provides rigid, flex-free movement.
- **Unique roller bearing and shaft design** – The telescope base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounted for imaging.

Standard Equipment & Specifications

	NexStar 8 GPS	NexStar 9.25 GPS	NexStar 11 GPS
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	Yes
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	**$1999**	**$2699**	**$2999**
Shipping & Handling	$95	$115	$125

NEW 2003 PRODUCT GUIDE

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**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included. ***120V AC Adapter included for U.S.A. and Canada only.

NEW Celestron StarBright® XLT High Performance Optical Coatings Outperform The Competitor's UHTC.

StarBright XLT — An Optical System Breakthrough! Celestron has taken its renowned StarBright technology to *an even higher level of light transmission* with the introduction of our new **optional** StarBright XLT High Performance Optical Coating System.

StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

- **11% brighter than UHTC across the spectrum from 400nm to 750nm.** (See Fig.#1)
- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

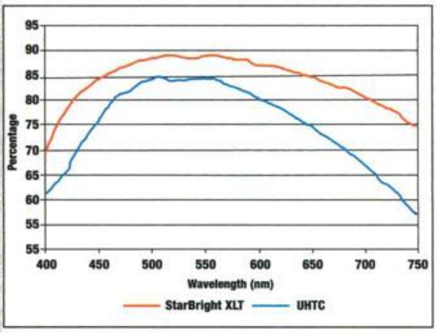

Fig #1: *This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

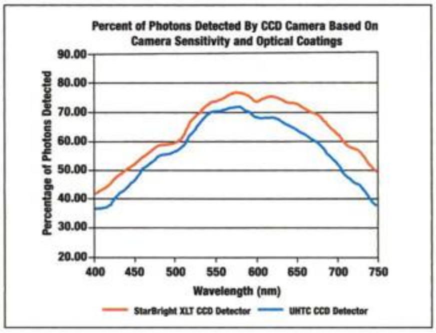

Fig #2: *StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

Coming Out of the Dark — StarBright XLT Performance Where It Counts

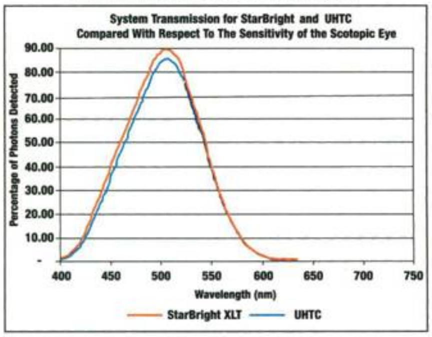

Fig #3: *The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a* ***6% improvement over UHTC*** *for visual observing .**

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt**.*

****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO_2 (quartz), TiO_2 (titanium dioxide), and SiO_2. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of MgF_2 (magnesium fluoride), and HfO_2 (hafnium oxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings.*** That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

For more information about StarBright XLT visit: www.celestron.com/starbrightxlt

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products	$125
All 9.25" Schmidt-Cassegrain Products	$175
All 11" Schmidt-Cassegrain Products	$225
All 14" Schmidt-Cassegrain Products	$275

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

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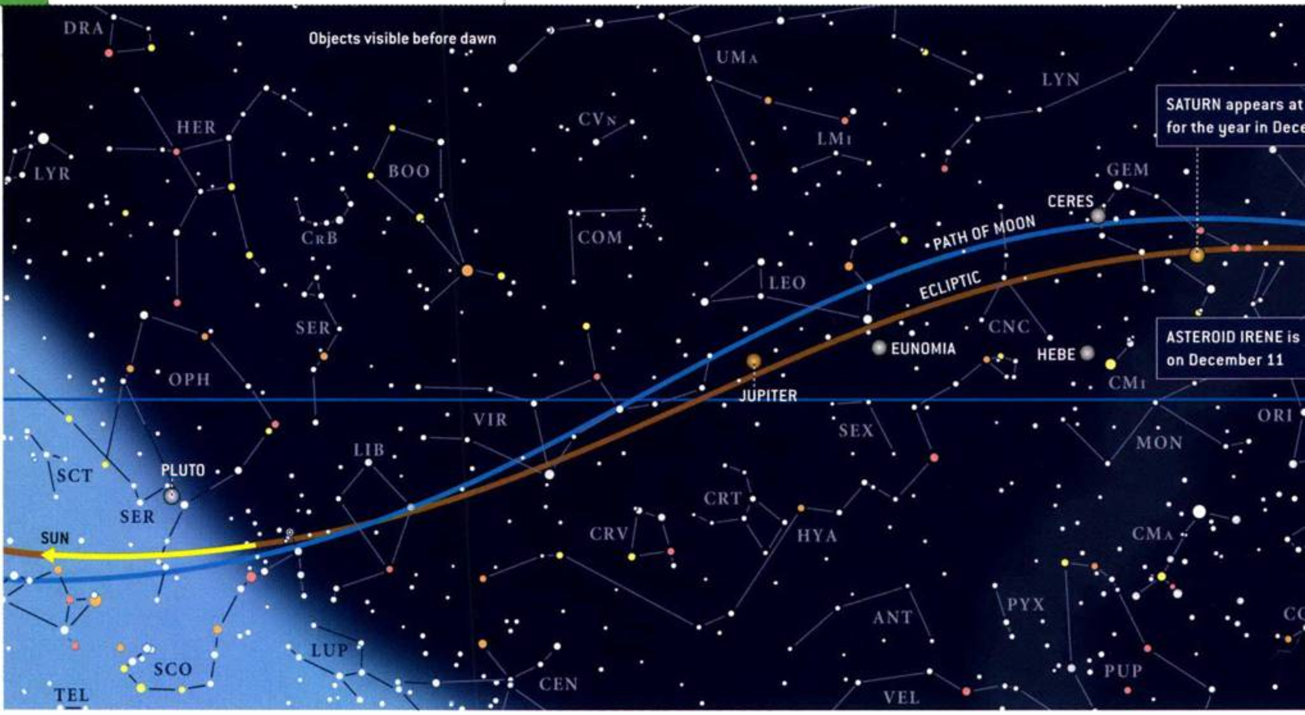
StarBright XLT is a trademark of Celestron.

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and


DRA
Objects visible before dawn
UMA
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BOO
GEM
CERES
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COM
PATH OF MOON
LEO
ECLIPTIC
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CNC
EUNOMIA
HEBE
OPH
CMI
JUPITER
ORI
VIR
SEX
MON
LIB
SCT
PLUTO
CRT
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CMA
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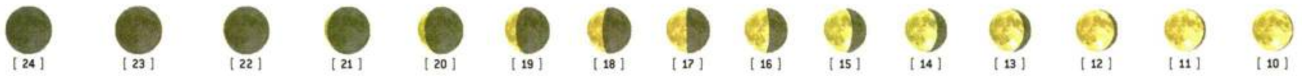
SATURN appears at
for the year in Dece

ASTEROID IRENE is
on December 11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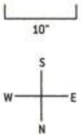
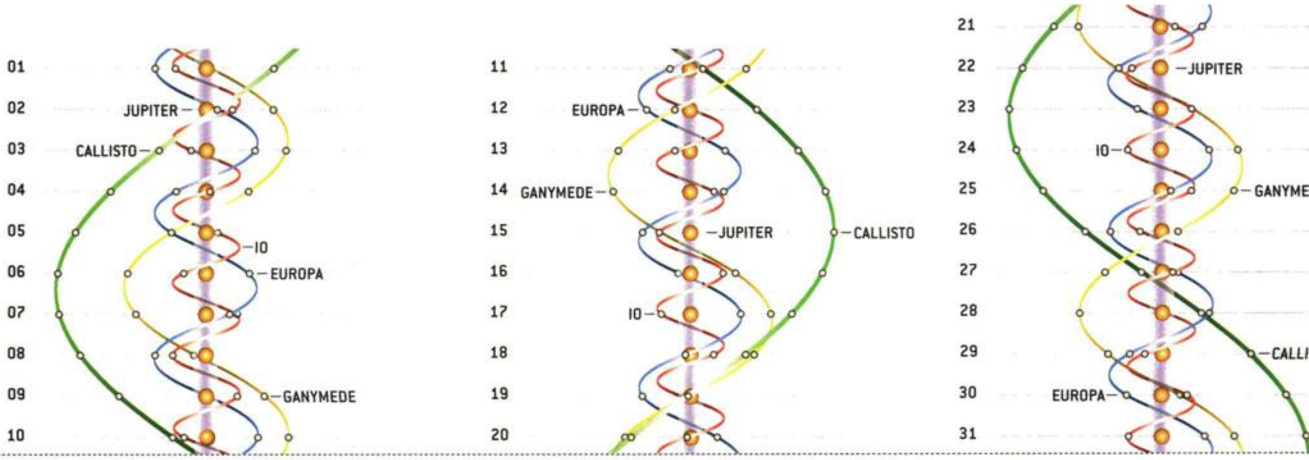
To locate the Moon in the sky, draw a line from the phase shown fo



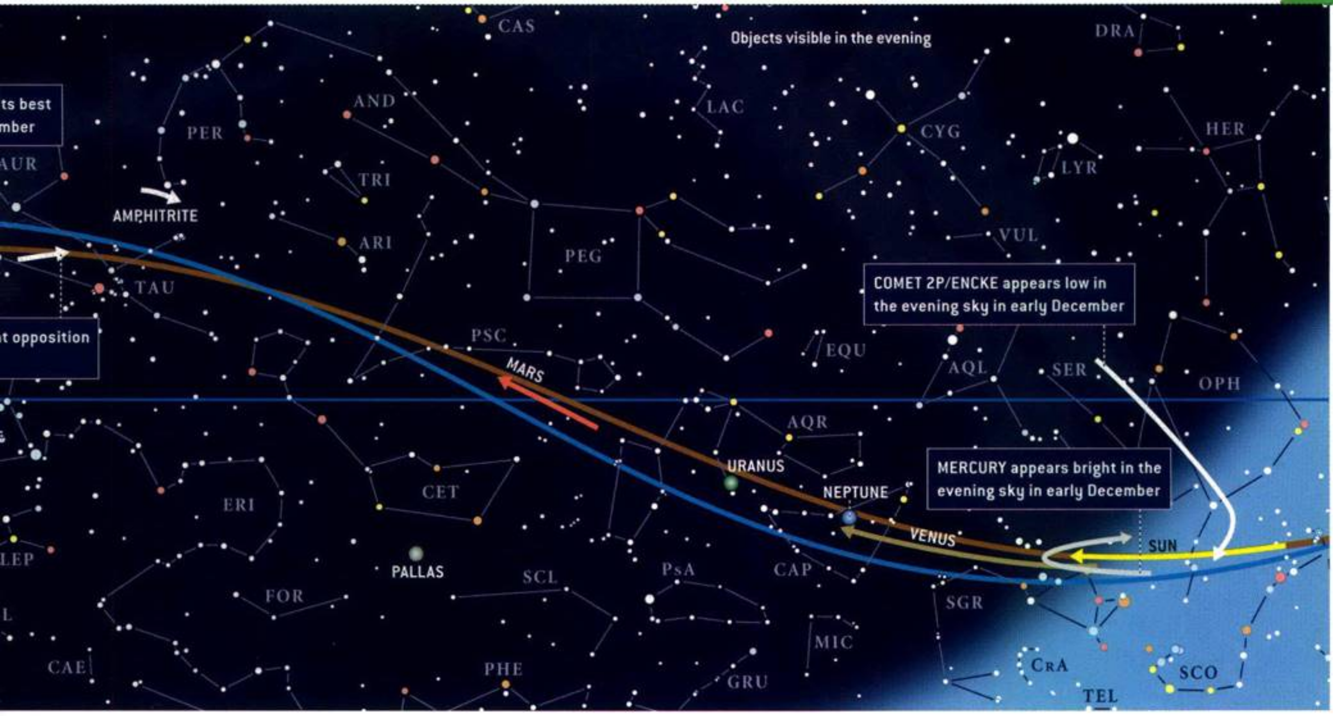
PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS
Date	December 1	December 15	December 15	December 1	December 31
Magnitude	–0.5	0.0	–4.0	–0.4	0.2
Angular Size	5.7"	7.7"	12.0"	11.0"	8.5"
Illumination	80%	41%	87%	87%	87%
Distance (AU) from Earth	1.181	0.871	1.395	0.848	1.102
Distance (AU) from Sun	0.410	0.332	0.728	1.437	1.473
Right Ascension (2000.0)	17h48.5m	18h52.3m	19h37.1m	23h29.3m	0h31.2m
Declination (2000.0)	–25°50'	–24°06'	–23°19'	–4°17'	3°24'

Jupiter's moons

Dots display positions of Galilean satellites at 4 A.M. EST on date shown. South is at top to match the view in a telescope.



colored dots show motions and locations of solar system objects during the month.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Objects visible in the evening
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OPH
AQR
URANUS
NEPTUNE
VENUS
SUN
ERI
CET
LEP
PALLAS
SCL
PsA
CAP
SGR
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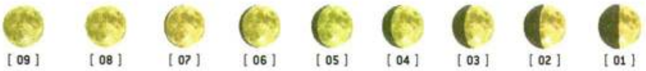
SCO
TEL

COMET 2P/ENCKE appears low in the evening sky in early December

MERCURY appears bright in the evening sky in early December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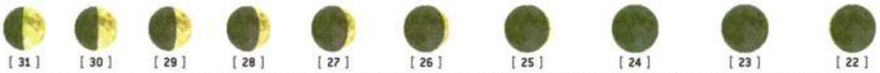
the day straight up to the curved light-blue line.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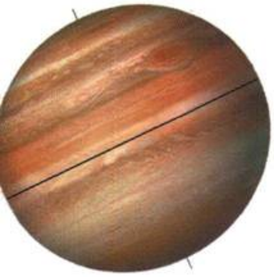
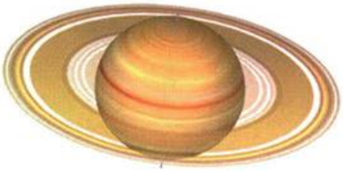
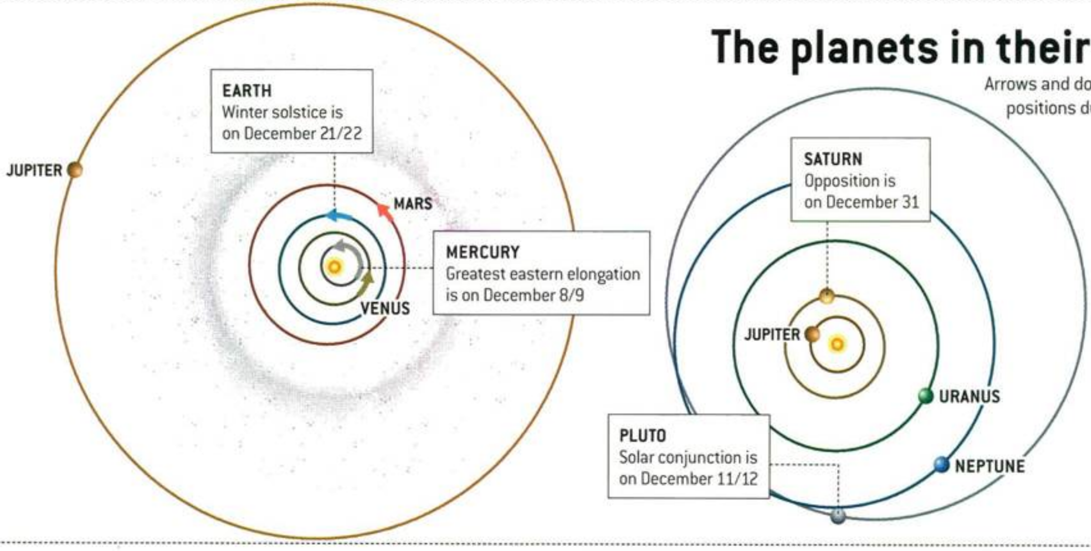




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
December 15	December 15	December 15	December 15	December 15
−2.1	−0.4	5.9	8.0	13.9
37.6"	20.5"	3.5"	2.2"	0.1"
99%	100%	100%	100%	100%
5.237	8.094	20.403	30.717	31.704
5.400	9.033	20.037	30.075	30.732
11h18.4m	6h47.9m	22h07.1m	20h54.3m	17h18.4m
5°42'	22°17'	−12°23'	−17°28'	−14°26'

The planets in their orbits

Arrows and dots show planets' positions during the month.


E
TO
JUPITER
MARS
VENUS
JUPITER
URANUS
NEPTUNE

EARTH
Winter solstice is on December 21/22

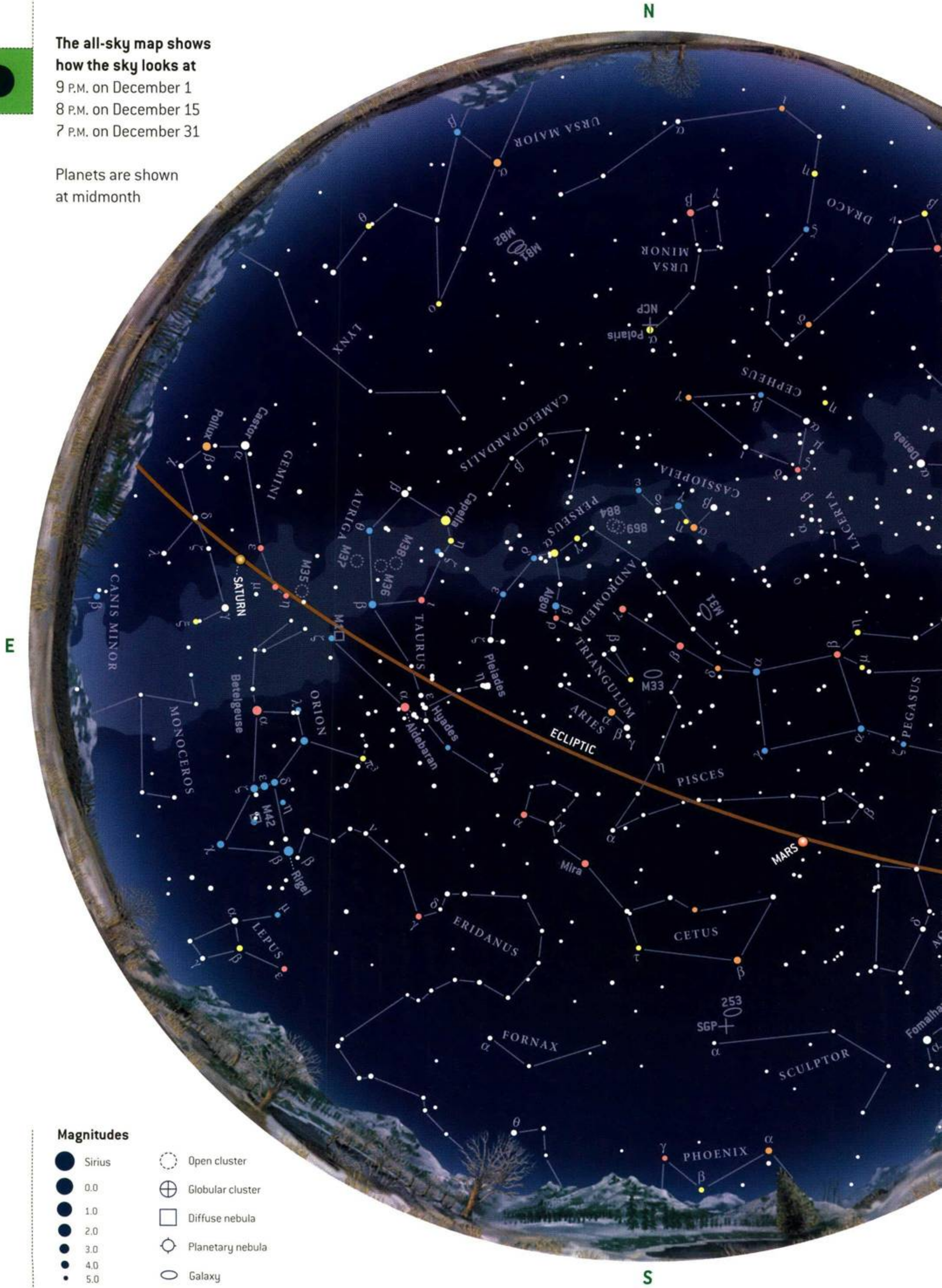
MERCURY
Greatest eastern elongation is on December 8/9

SATURN
Opposition is on December 31

PLUTO
Solar conjunction is on December 11/12

The all-sky map shows how the sky looks at
9 P.M. on December 1
8 P.M. on December 15
7 P.M. on December 31

Planets are shown at midmonth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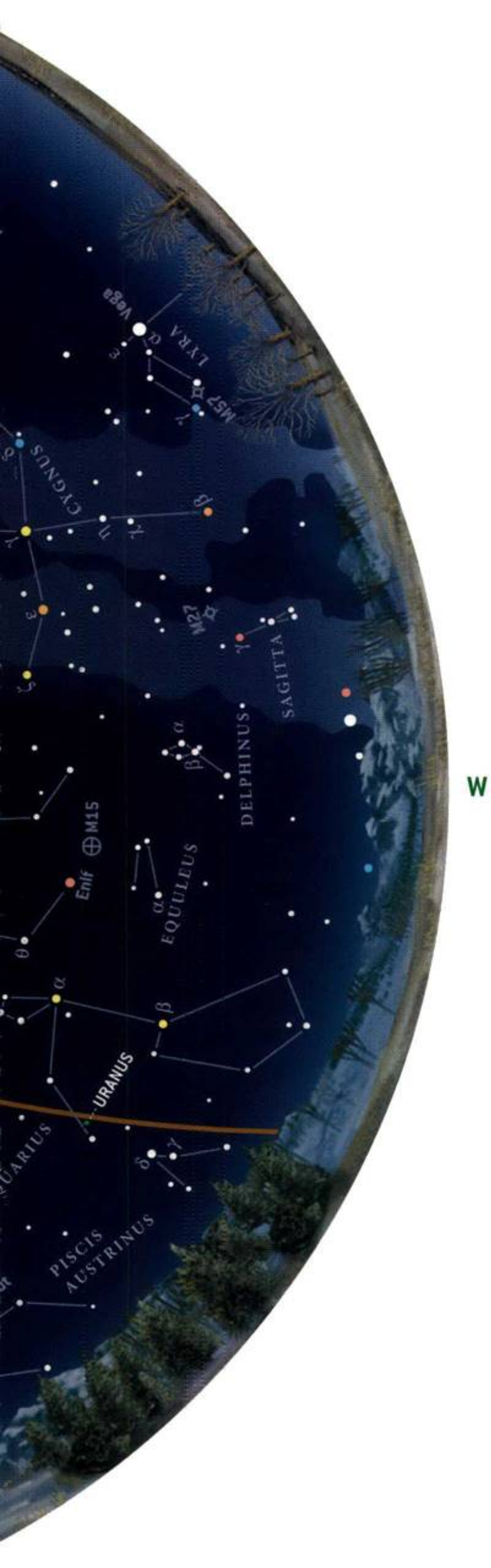
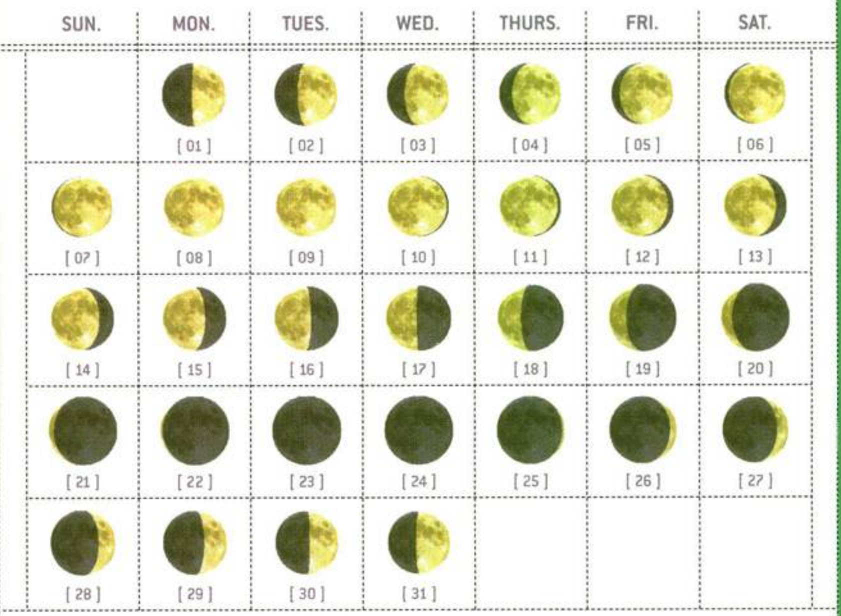
S
URSA MAJOR
M81
M82
LYNX
URSA MINOR
NCP
Polaris
DRACO
CEPHEUS
Deneb
CAMELOPARDALIS
CASSIOPEIA
LACERTA
Pollux
Castor
GEMINI
SATURN
CANIS MINOR
AURIGA
Capella
M37
M38
M36
M35
M1
PERSEUS
884
869
Algol
ANDROMEDA
M31
TRIANGULUM
M33
PEGASUS
TAURUS
Pleiades
Hyades
Aldebaran
ARIES
ECLIPTIC
PISCES
MONOCEROS
Betelgeuse
ORION
M42
Rigel
LEPUS
ERIDANUS
Mira
CETUS
MARS
253
SGP
FORNAX
SCULPTOR
Fomalhaut
PHOENIX
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: nort
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


Vega
LYRA
M57
CYGNUS
M27
SAGITTA
DELPHINUS
M15
Enif
EQUULEUS
URANUS
AQUARIUS
PISCIS AUSTRINUS
W

december 03


SUN.
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01 The Moon passes 4° south of Mars, 11 A.M. EST

07 The Moon is at apogee (252,450 miles from Earth), 7:04 A.M. EST

08 Full Moon is at 3:37 P.M. EST

09 Mercury is at greatest eastern elongation (21°), 1 A.M. EST

10 The Moon passes 5° north of Saturn, 5 P.M. EST

11 Asteroid Irene is at opposition, 2 P.M. EST

Pluto is in conjunction with the Sun, midnight EST

14 Geminid meteor shower peaks

15 The Moon passes 4° north of Jupiter, 11 P.M. EST

16 Last Quarter Moon is at 12:42 P.M. EST

22 Winter solstice is at 2:04 A.M. EST

The Moon is at perigee (222,661 miles from Earth), 6:50 A.M. EST

23 New Moon is at 4:43 A.M. EST

25 The Moon passes 3° south of Venus, 11 A.M. EST

The Moon passes 5° south of Neptune, 8 P.M. EST

26 Mercury is in inferior conjunction, 8 P.M. EST

27 The Moon passes 5° south of Uranus, 3 A.M. EST

30 The Moon passes 4° south of Mars, 2 A.M. EST

Venus passes 1.9° south of Neptune, 2 A.M. EST

First Quarter Moon is at 5:03 A.M. EST

31 Saturn is at opposition, 4 P.M. EST

h, south, east, and west. To find stars above your

Here's An Eye-Opening Offer!

ACCESSORY KIT

Purchase any Celestron telescope and buy this exclusive Filter and Eyepiece Accessory Kit for ONLY $99!*

32mm PLÖSSL
15mm PLÖSSL
2x Barlow
9mm PLÖSSL
6mm PLÖSSL
4mm PLÖSSL
No. 21
No. 56
No. 80A
No. 12
No. 25
No. 58A
Moon

Seeing is believing!

Purchase **any** Celestron telescope **between September 15, 2003 and December 31, 2003**, and buy this exclusive Celestron Filter and Eyepiece Accessory Kit from your dealer for **ONLY $99**.

The Filter and Eyepiece Kit (#94303) contains:

- **Five Superior Grade Plössl Eyepieces** - 1.25" — 4-element design with a 52 AFOV (32mm has 44°) — Superb color, resolution, edge sharpness and clarity. All eyepieces are fully multi-coated for maximum contrast and resolution. Supplied are a 4mm,6mm, 9mm, 15mm, and 32mm.

Rugged carrying case is included!

- **Barlow Lens** - 2x 1.25" — Compliments the Plössl eyepieces in this kit and gives you a total of ten power combinations. High grade glass optics with fully multi-coated lenses are used so there is no degradation of image.
- **Six Colored Eyepiece (Planetary) Filters** - 1.25" — Included are Kodak Wratten #12, #21, #25, #56, #58A, and #80A. Since you have all the eyepieces necessary to study the planets and moon in detail, these filters will greatly enhance your enjoyment of our solar system.
- **Moon Filter** - 1.25" — A neutral density filter which allows you maximum enjoyment of the moon especially during the brighter phases.
- **Aluminum Carrying Case** — This sturdy and well-built case fits all of the above items in the die-cut foam interior and has room for additional accessories.

***This special $99.00 offer ends Dec. 31, 2003.**

The items in this kit are valued at over $700.00 if purchased separately!

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CELESTRON ACCESSORIES

FOR MORE INFORMATION OR TO LOCATE AN AUTHORIZED CELESTRON DEALER, VISIT: WWW.CELESTRON.COM

OMNI® Eyepieces — 11/4"

- Focal lengths – 4mm, 6mm, 9mm,12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52º (43º for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens—11/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow............$ 47.00

X-Cel® Eyepieces — 11/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm,10mm, 12.5mm,18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

2.3mm	$ 69.00	12.5mm	$ 69.00
5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

E-Lux® Eyepieces 2"

- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces —11/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plössl optical design
- Fully-coated

2":		1-1/4":	
26mm	$ 69.00	6mm	$ 34.00
32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces —11/4", 2"

- Focal lengths –
  1-1/4": 15mm, 19mm, 23mm
  2": 19mm, 34mm, 40mm, and 50mm
- **7-element optical design**
- ***70° EXTRA WIDE*** field of view (except 50mm)
- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
50mm	$329.00

Ultima® Eyepieces —11/4"

- **5-element hybrid optical design**
- Focal lengths – 5mm, 7.5mm, 12.5mm, 18mm, 30mm, 35mm, and 42mm
- Fully multi-coated
- Blackened lens edges

5mm	$ 79.00
7.5mm	$ 79.00
10mm	$ 79.00
12.5mm	$ 79.00
18mm	$ 79.00
30mm	$ 99.00
35mm	$109.00
42mm	$ 99.00

10mm Plössl Reticle Eyepiece —11/4"

- Five-element guiding eyepiece
- Reticle pattern is a .0075" double spaced line system
- Multicoated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
- 50° apparent field of view
- Optional illuminator is required

10mm Plössl Reticle Eyepiece —11/4"............$124.00

Ultima® 2x Barlow —11/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece —11/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars

Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C91ı4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

Stereo Binocular Viewer

- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

Stereo Binocular Viewer.......$649.00

Power Tank™

- 12-volt rechargeable power supply
- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank............$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)............$ 59.00

Contrast-Booster Filter —11/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter............$ 49.00

Model A — for 1-1/4" eyepieces

Model B — for backthreads of SC's

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"	$ 69.00
LPR Filter Model B	$ 99.00

11/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets —11/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)	$ 44.00
#94119-20 (12, 25, 56, ND-25)	$ 44.00
#94119-30 (23A, 38A, 58, ND-50)	$ 44.00
#94119-40 (8, ND-13, 47, 82A)	$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision Flashlight.......$ 19.00

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310.328.9560 • www.celestron.com

Note: All prices shown are suggested mail-order.
All prices shown in U.S. Dollars.

THE DEEP SKY

Comet Encke draws our attention to the splashy star clusters of Serpens Cauda and northern Ophiuchus.

Encke targets clusters

Unless you have a go-to telescope, your best bet for finding celestial objects is to start with a reference point and navigate from there. Using a good star atlas, find the triangle of bright stars labeled Alpha (α), Beta (β), and Kappa (κ) Ophiuchi, which will be hanging low in the western sky soon after darkness falls. Aim your binoculars at Beta. Surprise — you'll see a field with several bright stars topped off by a large, splashy cluster.

This big group is IC 4665, arguably the easiest object in the *Index Catalog* to find in the northern sky. Without modern wide-angle eyepieces, the prolific visual observers of the 18th and 19th centuries scanned right over it. At high power, they saw a few trees but no forest. IC 4665 spans nearly two Moon widths.

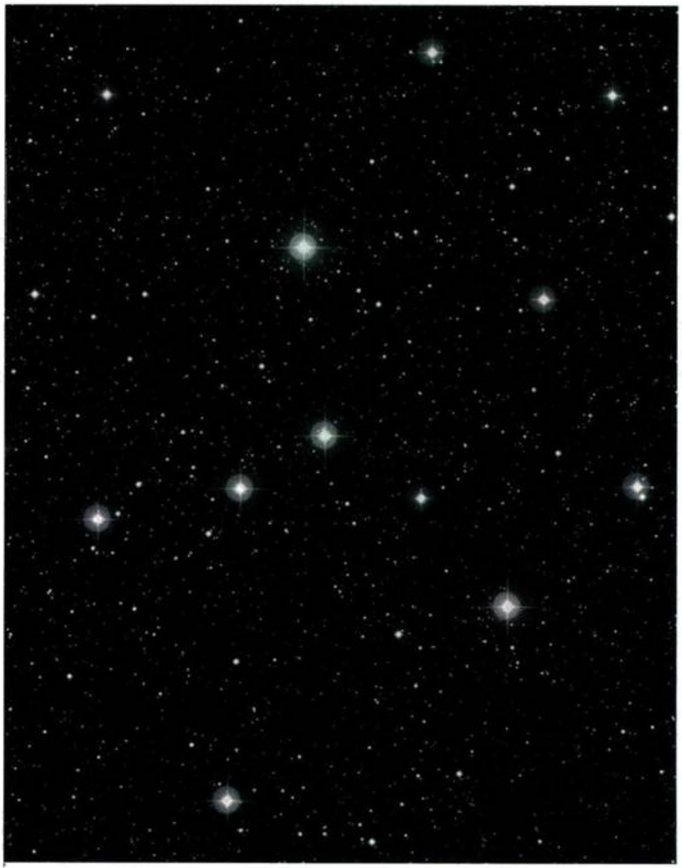
Slide two binocular fields east of IC 4665 and you'll land on the double gem NGC 6633 and IC 4756, both prominent star clusters under a dark sky. If you skywatch from town, you'll likely see just NGC 6633 because it appears brighter and more compact. IC 4756 looks like a detached piece of the Milky Way. Any small telescope will show how different these two star clusters really are: One is bright and splashy with numerous pairs, the other is a mound of stardust with some added sparkles.

Chances are you're in this area of sky because of Comet 2P/Encke's proximity. On the nights of December 2 and 3, the comet passes just 1° from the double star 70 Ophiuchi. At low power, this system looks like a single star, but punching up the magnification to 150x or more should reveal the fainter companion located a scant 4.7" away. This separation is somewhat wider than that between the components of the famous "Double Double" in Lyra.

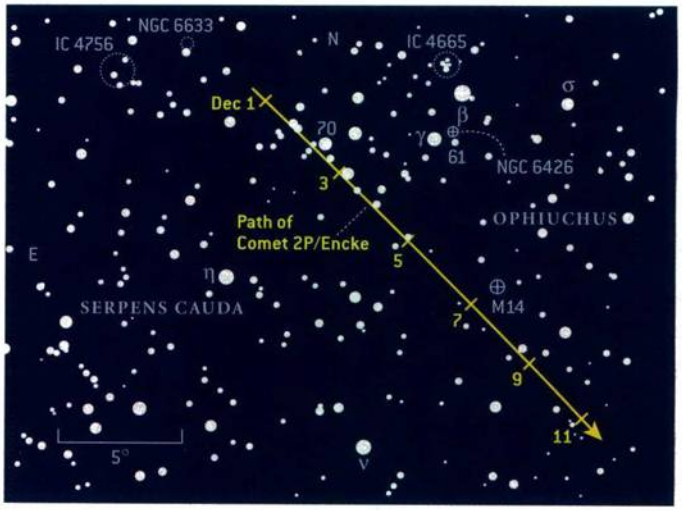
Not quite 1° due west of Gamma (γ) Ophiuchi lies a pair of 6th-magnitude, white stars. Medium power on a small telescope handily splits the duo, whose separation is 20", about two-thirds of the gap you'll find on the well-known Albireo (Beta Cygni).

If you think you've discovered a comet just north of 61 Ophiuchi, look again. It is actually a globular star cluster, NGC 6426. At magnitude 11.1, it glows somewhat fainter than Comet C/2002 T7 (LINEAR) (see page 71). Jump back and forth between them, comparing the quality of their light. An experienced comet hunter will know not to get excited based on an object's visual texture. Note that both comets Encke and C/2002 T7 show one edge sharper than the other, whereas globulars appear the same all around.

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist with Environment Canada.*

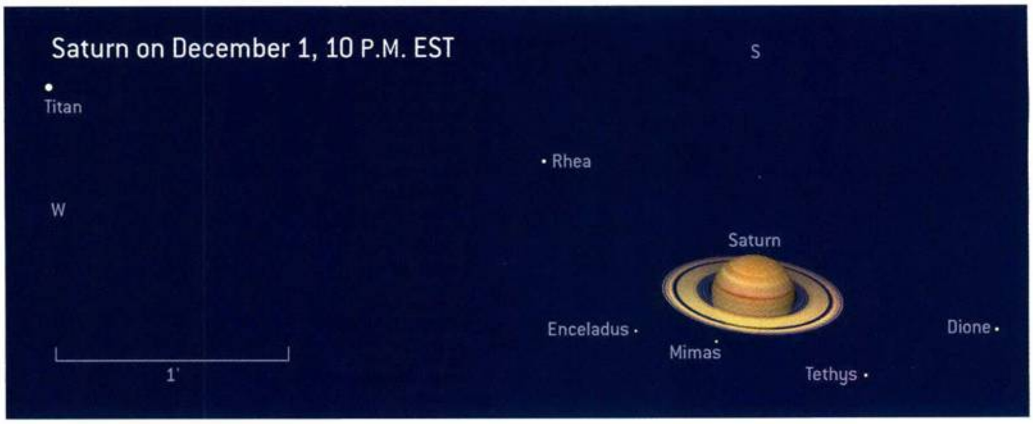


COMET ENCKE PASSES near a number of star clusters this month, most noticeably the bright and splashy IC 4665. DIGITIZED SKY SURVEY



THE PLANETS

As the Red Planet bows out as the evening target of choice, the Ringed Planet takes center stage with an equally impressive apparition.



Saturn on December 1, 10 P.M. EST

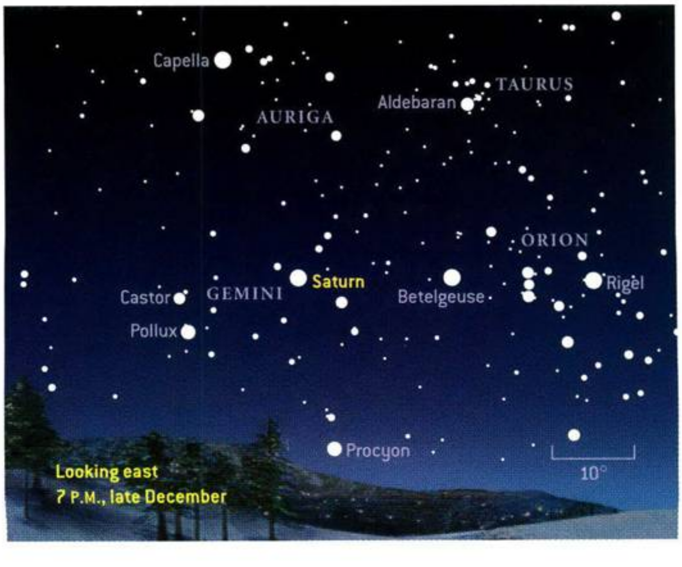
While many observers may feel melancholic over Mars, whose disk now spans less than half of what it did at its peak this past summer, fear not. As the Red Planet bows out "stage west," the real lord of the rings rises in the east. We speak, of course, of the planet Saturn. No other planet dazzles both novice and experienced viewers the way Saturn does. By the time New Year's Eve rolls around, Saturn appears at its best for the year.

So, travel around the sky from dusk to dawn and capture this month's planetary highlights. The early evening sky holds five planets for our potential viewing.

We start with **Mars**, shining at magnitude –0.4 as the month begins. After sunset on December 1, you'll find Mars glowing a distinct orange color among the background stars of Aquarius, some 5° northwest of the waxing gibbous Moon. During December, Mars continues to slink away from Earth. Consequently, it dims (crossing the zero-magnitude threshold) and diminishes in apparent size (falling below 10" in diameter). Through a telescope, Mars has taken on a distinctly gibbous phase, with its 87-percent-illuminated globe easily recognizable. It remains visible all evening, setting after midnight throughout December.

The shrinking disk of Mars means most observers will see only the more obvious features. Early December finds Mare Sirenum well placed around 8 P.M. EST. By early in the second week, the distinct dark feature Solis Lacus comes into view during the evenings. At 8 P.M. EST on December 14, the broad Mare Erythraeum is prominently displayed. Its finger-like extension, Sinus Sabaeus, slides into view later in the evening, but Mars will have fallen below 10" in diameter by then. As the Red Planet continues to shrink in late December, Syrtis Major and the bright Hellas region are evening targets. Can you make out the remnants of the south polar cap this late in the Mars observing season?

Although Mars still attracts our attention, don't forget to grab your binoculars and check out **Uranus**. It lies at the western edge of Aquarius, some 30° west of Mars in mid-December. It stands 1.5° north of Iota (ι) Aquarii, a 4.3-magnitude star that's easy to spot under a dark sky. Uranus shines at magnitude 5.9, putting it within easy reach of 7x50 binoculars.

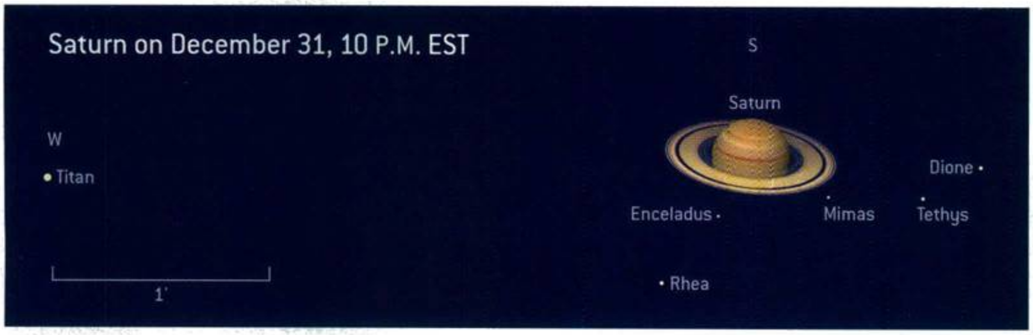


Looking east
7 P.M., late December

Challenging **Neptune** lies west of Uranus in central Capricornus. It sets before 10 P.M. local time on December 1 and a few minutes earlier each day afterward. (Uranus sets more than an hour later.) Good, tripod-mounted binoculars will show Neptune, but you'll need a telescope (perhaps the one you're hoping to get for Christmas) to positively identify it. Shining at magnitude 8.0, Neptune lies 3° southwest of Theta (θ) Capricorni.

December also offers brief glimpses of the two inner planets, Mercury and Venus. You'll find them low in the southwest shortly after sunset. **Mercury** reaches greatest elongation on December 8/9, when it lies 21° east of the Sun. Shining at magnitude –0.4, it should be fairly easy to spot thirty minutes after sunset.

Saturn on December 31, 10 P.M. EST



Venus stands 8° to the upper left of Mercury that evening and shines brilliantly at magnitude –3.9. The 2nd-magnitude star Sigma (σ) Sagittarii lies roughly midway between the two planets. Through a telescope, Venus displays an almost fully illuminated disk while Mercury's disk wanes, shrinking from 69 percent illumination on December 7 to 53 percent on the twelfth.

Shortly after Venus sets in early December, **Saturn** rises in the east-northeast. On New Year's Eve, the Ringed Planet reaches opposition, rising at sunset and appearing brighter and larger than at any other time of the year. Although its disk size never exceeds Mars's at a good opposition, Saturn reaches 21" across on December 31. Including the rings, the entire saturnian system spans 47" at the widest point.

Saturn floats among the stars of Gemini the Twins. During the next few months, Saturn's retrograde, or westward, path takes it away from Castor and Pollux, the bright pair of stars at the northeastern end of the constellation.

The southern face of Saturn's rings tilt 25° toward our view, giving us a clear view of the planet's south pole. The rings split into a number of segments when viewed from Earth. The outer Ring A and brighter Ring B appear most obvious. Ring B overshadows the faint Ring C, often called the Crepe Ring, which lies inside it. Small telescopes have difficulty showing the Crepe Ring, but larger telescopes can reveal the disk of the planet shining through it, such is that ring's tenuous nature.

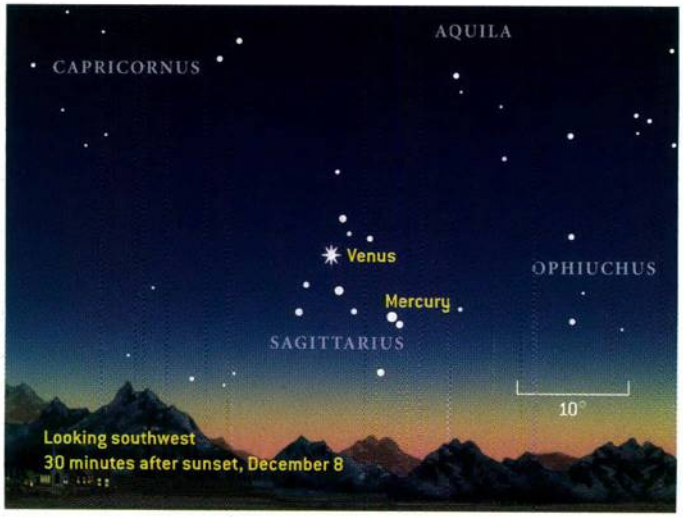
The globe of Saturn, which spans 21" at month's end, carries subtle cloud features that require the same patience to view as the fainter features on Mars. A quick glance at the planet through the eyepiece denies you the truly superb moments of perfect viewing that await the patient observer. Brief periods of still air provide stunning views of subtle colors and atmospheric bands. Although Saturn's atmosphere is as dynamic as Jupiter's, haze creates a challenge in trying to view Saturn's features.

Saturn rotates once every 10 hours and 40 minutes, almost as fast as Jupiter. Any spots visible in the saturnian atmosphere get carried by this rotation, although such spots appear only rarely.

Saturn's family of satellites continues to grow with new discoveries in recent years. A number of the larger, brighter satellites can be seen through modest scopes. The brightest is Titan, easily spotted in a 3-inch scope. It shines at magnitude 8.3 and circles Saturn in 16 days. Nightly observing of Saturn will reveal Titan's motion, most easily recalled if you note the moon's position relative to Saturn in a logbook.

Iapetus ranks as perhaps the most fascinating of all Saturn's moons. It brightens and fades as it orbits its parent planet because one hemisphere is covered with far brighter material than the opposite hemisphere. Iapetus always appears brightest, at magnitude 10.1, when it lies on the western side of Saturn. It dims by a factor of five, to magnitude 11.9, on the eastern side, all but disappearing in small scopes. Iapetus takes 79.3 days to complete one orbit around Saturn. During the first few days of December, Iapetus lies east of Saturn and appears rather faint. Follow the moon during December as it moves west of Saturn and brightens.

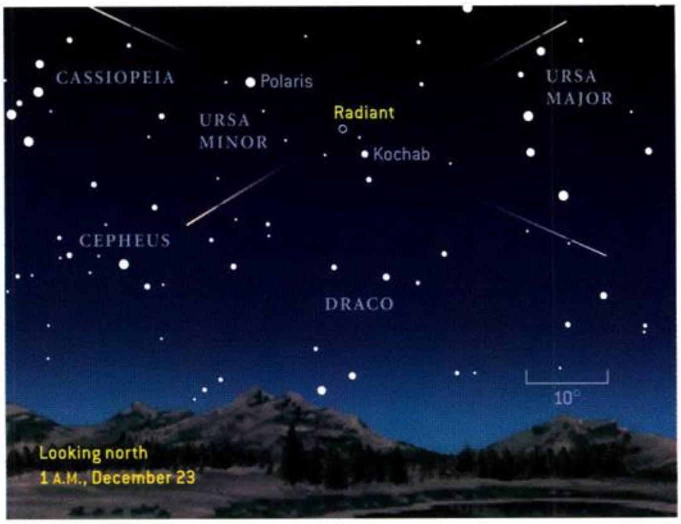
Jupiter lies near the hind legs of Leo the Lion this month. The planet rises in the east shortly before midnight in the middle of the month. Jupiter looms large in telescopes, even when compared to memories of Mars this past summer. Anyone who bought a telescope for viewing Mars should really enjoy the sight of Jupiter. The giant planet grows brighter and larger during December as the distance between Earth and Jupiter shrinks. It reaches magnitude –2.2 and an apparent diameter of 40" by month's end. Early risers also can enjoy the nightly dance of Jupiter's four major moons: Io, Europa, Ganymede, and Callisto. Make a brief sketch of their relative positions to check the identity of each moon later.

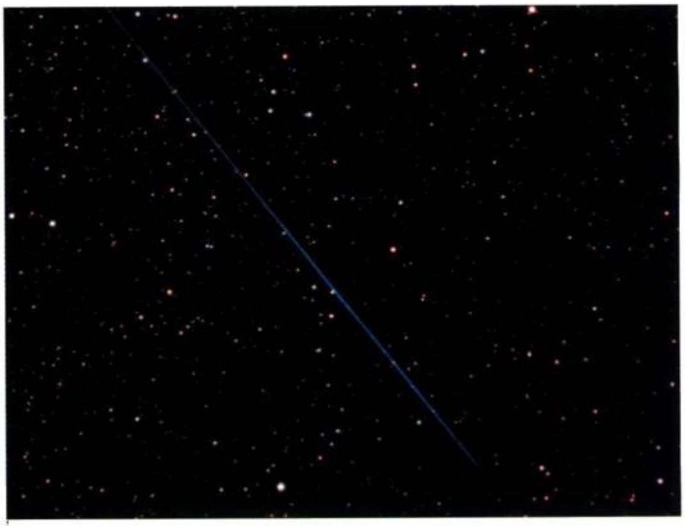


Looking southwest
30 minutes after sunset, December 8

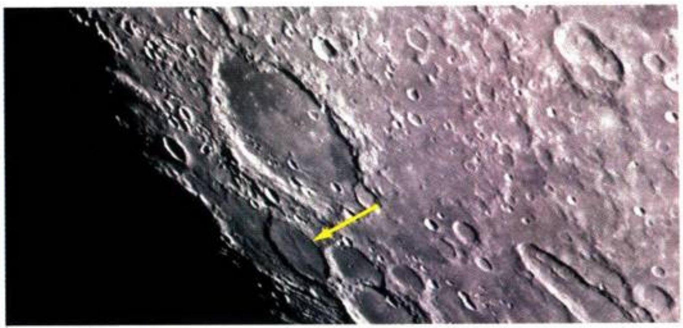
METEORS AND MOONS

A pair of meteor showers hits at opposite phases of the Moon, and a lava-filled lunar crater struts its stuff during the second week of December.





THE GEMINID METEOR SHOWER, known for its many bright meteors, reaches its peak on December 13/14. FRANK ZULLO



THE LAVA-FILLED CRATER WARGENTIN (arrow) lies near the southwestern limb of the Moon, which causes it to appear noticeably foreshortened. FROM *CONSOLIDATED LUNAR ATLAS* (LPL/UA)

A pair of showers

The waning gibbous Moon has a considerable negative effect on this year's Geminid meteor shower. Shower activity runs from December 7 to 17, with the peak coming on the night of the 13/14th. Gemini remains visible nearly all night, rising shortly after sunset from northern latitudes.

The Moon rises around 9 P.M. local time on the 13th and an hour later the following night, offering observers a small window to catch some shower activity in a dark sky. Once the bright Moon rises, it will attenuate the number of visible meteors, leaving only the brighter ones. This shower is one of the most active of the year and usually produces a good percentage of bright meteors, so it's worth watching even under less-than-favorable conditions.

Unlike the reliable Geminids, the Ursid meteor shower proves highly variable. Over the past several years, rates for this shower have ranged from 10 to 50 meteors per hour. Although the higher rates are unusual, no one knows for sure what will happen this year. The peak of the Ursid shower occurs during the North American evening of December 22.

The radiant of the shower lies near the star Kochab (Beta [β] Ursae Minoris), a circumpolar star throughout most of the Northern Hemisphere; that means the radiant remains visible all night. The Moon helps out by moving out of the way, reaching new phase by the time of the shower's peak.

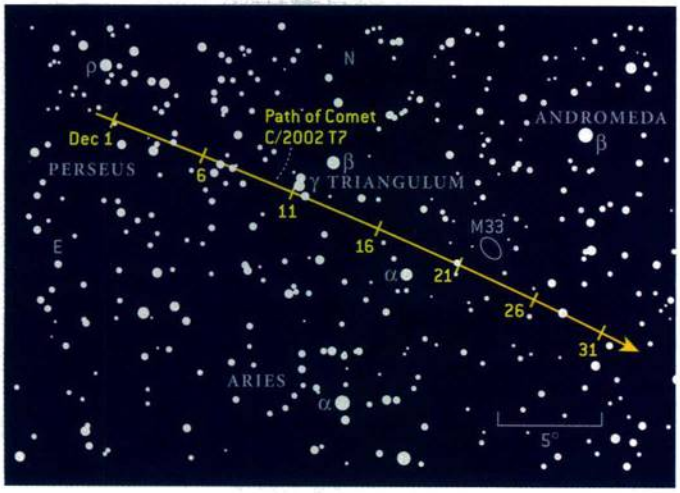
Wargentin looms

A large crater lies near the Moon's southwestern limb, but it appears smaller than it really is. Wargentin measures 52 miles (84 km) across but, due to its location, is highly foreshortened, so its east-west extent seems diminished. The crater also appears unusual because lava fills it to the brim. Wargentin shows up best with some shadow relief, which occurs a day or so before the Full Moon on December 8.

In the week following Full Moon, lunar libration favorably tilts the crater toward us. Plan to watch sunrise on Wargentin on or around December 6. Your view will reveal minor secondary craters around the main crater wall. On the floor of the crater, an unusual spiderlike array of wrinkle ridges emanates from the center of the lava floor. As the Moon passes full phase, the crater tilts more in our direction through December 14, when the distinctly foreshortened crater will appear a little more circular.

COMETS AND ASTEROIDS

Comet Encke proves to be a fine binocular sight after sunset, while Comet C/2002 T7 (LINEAR) waits to burst onto the scene.



Encke's final hurrah

After slicing through the Coathanger asterism on November 22 (see last month's *Astronomy* for a finder chart), Comet 2P/Encke continues to brighten this month as it approaches the Sun. Easily visible in binoculars from a city backyard, this primordial object made of ice and dust should glow at 7th magnitude in the evening sky.

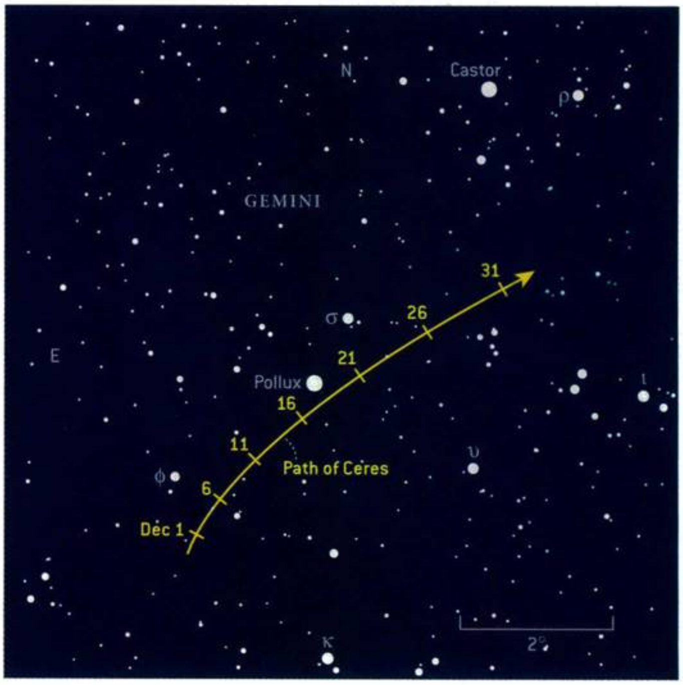
The comet's end is nigh, however, so you should plan ahead. Encke likely will be lost in the western twilight glow by December 11. Despite the light scattered by a gibbous Moon, the comet's diffuse glow will contrast nicely with the sparkles from some nearby star clusters (see the finder chart on page 67).

Encke's tail will stand straight up from the horizon, pointing toward the constellation Cygnus. The best view of this gossamer stream will be on December 9 and 10, before the bright Moon rises and kills the contrast. Sweep your binoculars or wide-field telescope back and forth as you scan upward to see how far you can trace the tail. Where the tail fades away, look for a change in the background sky brightness rather than for the tail itself.

When Encke reappears on February mornings, it will be on the far side of the Sun from our point of view. It will fade quickly and fall out of sight except for dedicated comet hunters with big scopes.

Passing the Pinwheel

Riding much higher in the evening sky, Comet C/2002 T7 (LINEAR) is only five months from its eagerly anticipated 1st-magnitude peak performance. From Earth's orbital perspective, C/2002 T7 is inbound from above. It will swing south of the Sun in spring before climbing northward next summer.



Observationally, the best views of this comet will come from a dark rural sky after midmonth, when the Moon has started to wane into a crescent. On the night of the maximum of the Geminid meteor shower, December 13/14, C/2002 T7 will be glowing at 9th magnitude within Triangulum's triangle of bright stars.

Those who enjoy taking wide-field images of the heavens have several nights of photo opportunities between the 20th and 26th. During this period, the comet passes within 3° of the majestic spiral galaxy M33, the Pinwheel.

As noted last month, at least two other dirty snowballs should be within reach of an 8-inch scope. Comet sleuths can get more details on-line at www.aerith.net/.

Pollux points to Ceres

Rising in the northeast during the late evening hours alongside Saturn are Castor, Pollux, and the asteroid 1 Ceres. Castor and Pollux are the two luminaries of Gemini; Pollux appears lower and slightly brighter than its "twin." Glowing at magnitude 7.4 in mid-December, Ceres hangs near the visual limit of standard 7x50 binoculars from a suburban backyard. A small telescope is all you need to track this Moon-like rock, which measures 580 miles (930 km) across. To make things really easy, it passes less than 1° south of bright yellow Pollux between the 13th and 23rd. ◼

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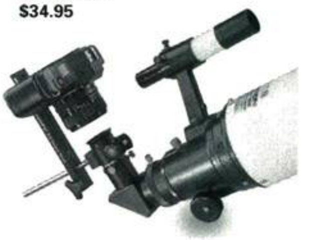

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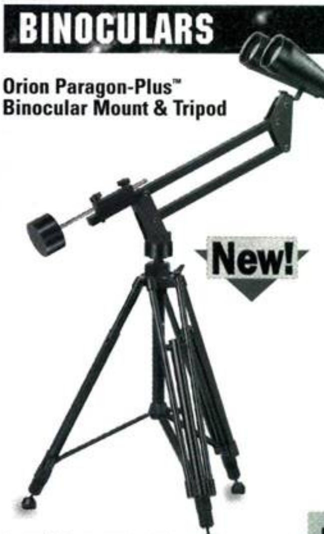

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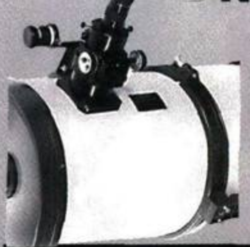

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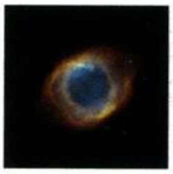
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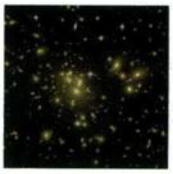
0004 Saturn 1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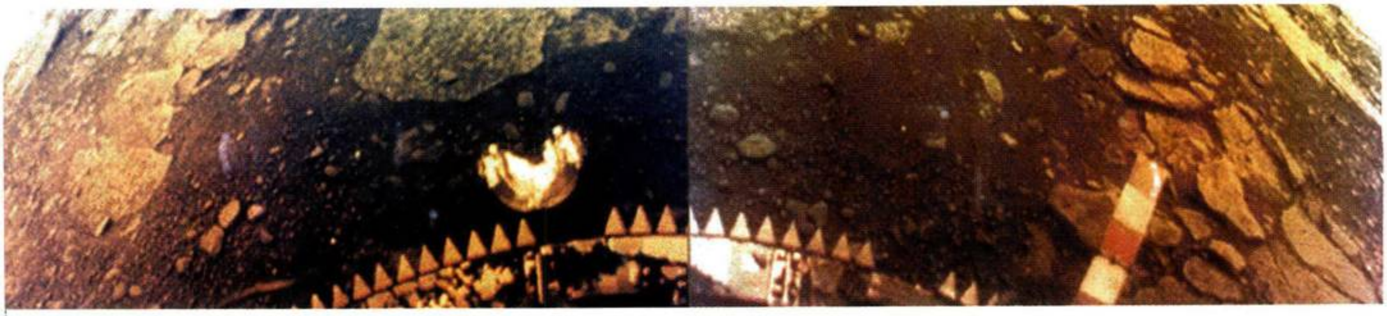
ASK ASTRO

Venus under pressure, setting circles, Europa's colors



REDDISH LIGHT bathes the surface of Venus as sunlight filters through its dense atmosphere, which is 92 times heavier than Earth's. This 170° panorama of Venus was taken by the Soviet Venera 13 lander, which survived on the surface only about two hours. SOVIET ACADEMY OF SCIENCES

VENUS UNDER PRESSURE

Why is Venus's atmospheric pressure so high? Is gravity's pull on atmospheric gases the principal cause of atmospheric pressure? — **HARVEY MONTGOMERY,** ELBERTON, GEORGIA

Gravity is indeed important in determining a planet's atmospheric pressure because that pressure is caused by the weight of the air pushing down from above. Venus, being slightly smaller in size and mass than Earth, has a slightly lower surface gravity — yet its atmospheric pressure reaches 90 times that of Earth. Obviously, gravity is not the only factor.

Atmospheric pressure also is determined by the total amount of gas in a planet's atmosphere. The balance of atmospheric sources and losses controls this inventory. Sources of fresh atmospheric gas include volcanoes, impacting comets, and the evaporation of surface materials. Losses occur by the escape of gas to space (air molecules move faster and escape easier the warmer an object is), impact erosion (air being blasted off into space by large meteorite impacts), and chemical reactions with surface minerals.

The amount of air that a planet can hang onto depends in part on the strength of its gravity because a smaller planet with a weak gravity is more vulnerable to atmospheric losses. That's why a tiny body like the Moon will never have much of an atmosphere.

For two planets with the same amount of atmosphere, the one with the higher surface gravity will have higher pressure. But in the case of Venus, the huge amount of carbon dioxide in its atmosphere makes the pressure so high. If Earth were heated enough so that all of its carbonate rocks (such as limestones) decomposed, returning all the trapped carbon dioxide to the air, then the pressure of our atmosphere at Earth's surface would be as great as that of Venus. I recommend avoiding this experiment. — **DAVID H. GRINSPOON,** SOUTHWEST RESEARCH INSTITUTE, BOULDER, COLORADO

SETTING CIRCLES

I have a 6-inch f/5 Newtonian telescope on a German equatorial mount. I am confused about the right ascension (R.A.) and declination (Dec.) settings. When I try to use the celestial coordinates given in *Astronomy*, I find that my scope is not pointing where it should be. I have precisely aligned my scope to Polaris using the latitude adjuster and the polar alignment scope. What should the setting circles read when the scope is polar aligned? — **BOB MOORE,** MONKEY ISLAND, OKLAHOMA

Bob, you're almost there. Polar alignment of an equatorially mounted telescope is a key step to using setting circles — whether or not your telescope has a motor drive.

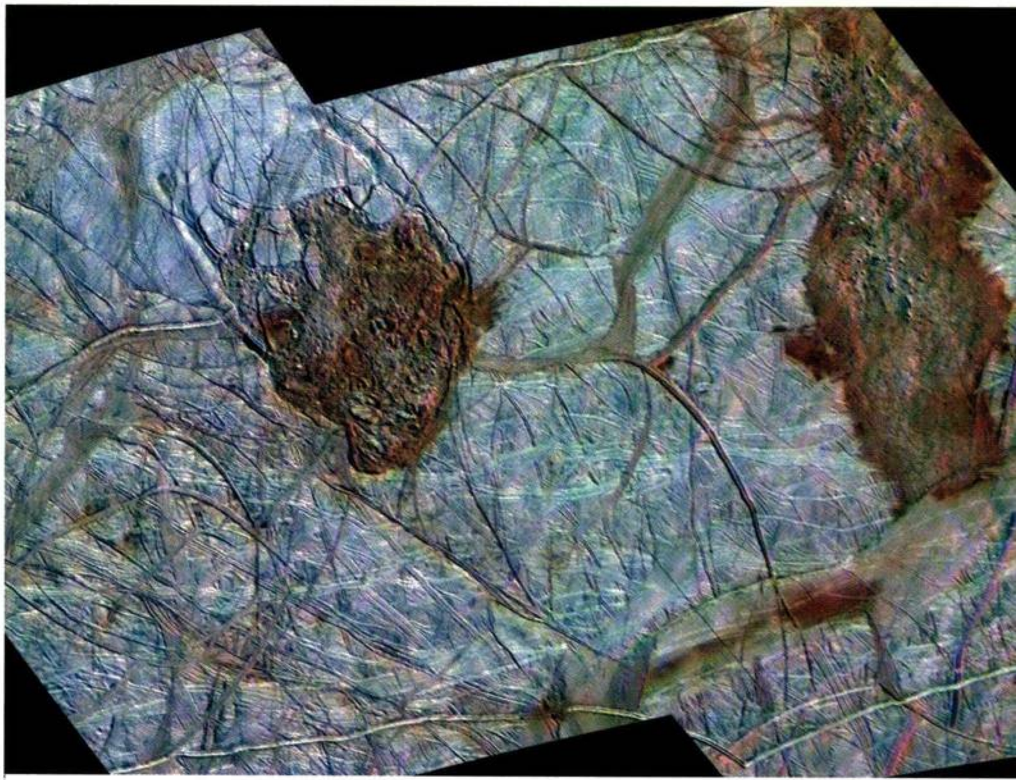
The easiest way of using setting circles to find a celestial object is to locate a bright star near your target. Use a book, star chart, or astronomy software to find the right ascension and declination of the star. Center the star in your eyepiece's field of view. *Without moving the telescope*, position the movable rings on the R.A. and Dec. scales on your telescope's mount to correspond to the right ascension and declination of the bright star. Finally, move the telescope until the R.A. and Dec. of the mount match the object you're trying to find. Look in the eyepiece and...*voilà*!

Here's an example: My telescope is set up and polar aligned. Using the setting circles on the mount, I want to locate the globular cluster M3. I find M3's approximate coordinates are R.A. = 13h42m, Dec. = 28°23'. On a star map, I notice the bright star Arcturus lies at R.A. = 14h16m, Dec. = 19°11'. I point my telescope at Arcturus, centering it in the eyepiece's field of view. I carefully move the rotatable rings on the setting circles until the right ascension scale reads 14h16m and the declination scale reads 19°11'. (Some eyeballing may be needed depending on how finely graduated the setting circles are.) Finally, I slowly swing the telescope over and up until the R.A. scale reads 13h42m and the Dec. scale reads 28°23'. When I look into the eyepiece, the beautiful globular cluster M3 should be centered in the field of view.

I have used setting circles often to locate planets or bright stars in the daytime, and so can you. For this procedure, the R.A. and Dec. of the Sun are needed for the particular date and time, and that brilliant object must first be centered in the telescope's field of view. In practice, I don't use the main telescope to "center" the Sun. It remains securely capped. Instead, I use a low-power finder scope, projecting the brilliant solar image onto a card. After re-capping the finder scope, I adjust the setting circles to match the R.A. and Dec. of the Sun, and then — using the procedure above — locate the planet or star. Only then do I uncap the main telescope. Don't pick objects too near the Sun and always remember to be very careful when pointing a telescope in the Sun's general direction. — **MICHAEL E. BAKICH,** ASSOCIATE EDITOR

EUROPA'S COLORS

I have noticed that many photographs of Jupiter's moon Europa show an area tinted orange. Is it a specific mineral, or are the photographs altered to show this color?
— **BRIAN PREECE,** NEVADA CITY, CALIFORNIA



MINERAL SALTS and chemical reactions from impacting particles both contribute to the orange-brown tinge coloring the icy surface of Jupiter's moon Europa. Bluish regions have relatively large ice grains. Where impacts have disrupted the moon's shell of ice, liquid water from the ocean below has helped spread the discoloring minerals. NASA/JPL

Most of Europa's surface is made of ice, but not all of the same variety. Images from the Galileo spacecraft show a reddish-orange color almost any place where the moon's icy surface has been breached by internal geological activity or a large impact. Most photos from Galileo have been exaggerated to show these areas as deeper red than they really are, but they truly are tinted an orange-yellow. Some color photos of Europa show bluish areas as well, but those photos are not showing the true color of the surface as our eyes would see it. Instead, the scientists used an infrared filter to identify where the ice grains on the surface are relatively dark and large.

Identifying mineral composition by color alone is always tricky. For example, minerals containing either iron or sulfur can be orange in color. Important clues have come from the Near Infrared Mapping Spectrometer aboard Galileo. This instrument records the fingerprints of minerals in the infrared portion of the spectrum where our eyes cannot see. In every instance where color photos show Europa's surface to be dark and ruddy, the infrared observations show signs of some hydrated mineral — that is, a mineral chemically bound to ice. The identity of this material isn't certain, but the probable candidates are salts such as magnesium sulfate (Epsom salt) or sulfuric acid (battery acid). Neither candidate mineral is dark nor red, however, so something else must be going on.

Europa's surface is bombarded constantly by high-energy charged particles that are trapped in Jupiter's powerful magnetic field. These particles include hydrogen, oxygen, and sulfur ions, most of which originate on Europa's volcanically active neighbor, the moon Io. When these fast-moving particles strike Europa's surface, they can tear apart chemical bonds and create new materials. If these particles rip apart sulfuric acid, then orange-tinted sulfur minerals can form. Also, because the high-energy particles hitting Europa include sulfur, sulfur can be implanted in Europa's ice as well.

Color photos of Europa record a complex cycle of creation and destruction of minerals on a surface bathed in radiation. It's most likely sulfur, some coming from volcanic Io and some created by high-energy radiation that breaks down other minerals on Europa's surface, that stains the surface orange. — **BOB PAPPALARDO,** UNIVERSITY OF COLORADO AT BOULDER

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ASTRONOMY: ROEN KELLY

Octans, Chamaeleon, and Volans

The Octant, Chameleon, and Flying Fish hide their deep-sky possessions in the dark realms around the South Celestial Pole. /// BY TOM POLAKIS

The constellations Octans, Chamaeleon, and Volans are the domain of observers in the Southern Hemisphere; if you live above 26° north latitude, they never clear your southern horizon, and if you live below 26° south latitude, they are circumpolar. Situated in a region between the Milky Way and the Magellanic Clouds, the three small constellations are nearly devoid of spectacular telescopic objects. But if we probe deeper, we will find some worthy targets indeed. ☾ Octans the Octant contains an ill-defined triangle of 4th-magnitude stars. Sigma (σ) Octantis is the best representation of a South Pole star. However, because the star glows dimly at 5th magnitude, you may find it easier to approximate the South Celestial Pole by forming an equilateral triangle with the two Magellanic Clouds.

Five stars between magnitudes 4 and 4.5 occupy the constellation Chamaeleon the Chameleon. This area is so sparse that the long form of the constellation is surprisingly easy to trace. At the west end, the nearby star Alpha (α) Chamaeleontis lies 63 light-years away and shines only eight times brighter than the Sun. Delta^1 (δ^1) and Delta^2 are separated by 4.3', making them a good test for naked-eye visual acuity. Do your eyes split the pair?

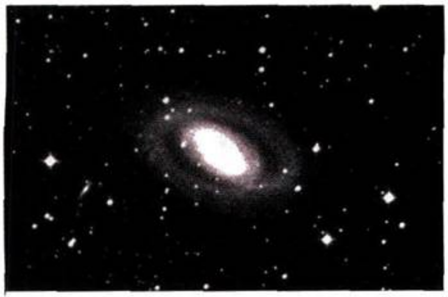
Tom Polakis *is an aerospace engineer and lives in Tempe, Arizona.*

Use your imagination to see Volans as the Flying Fish. Six magnitude 4 stars stand out well in this region. See whether you can distinguish the blue-white and orange hues of Epsilon (ε) and Beta (β) Volantis, whose spectral types are B6 and K2, respectively.

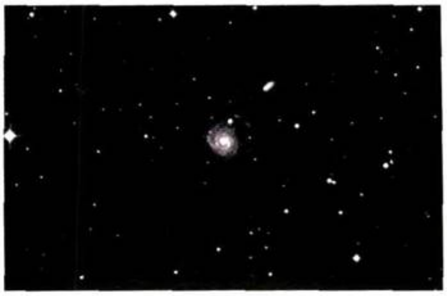
We will begin our telescopic tour in Octans with the isolated galaxy **NGC 7098**. Deep photographs show thin spiral arms surrounding an oval center. Through a 13-inch telescope, the galaxy measures 3' by 2' and is elongated in position angle (p.a.) 30°. The galaxy appears moderately bright with a broadly concentrated center. Look for a pair of 11th- and 12th-magnitude stars 6' to the southwest.

At first, **Melotte 227** presents a convincing case that it's an open cluster. Found by Philibert Jacques Melotte in 1915, the spray of twenty stars between magnitudes 7 and 10 contained within a circle less than 1° across represents twice the normal star density for the region. Only in 1998 did astronomers learn the stars do not have a common proper motion, so we now know it's only a random concentration of stars at various distances. It's still worth a look, though, and a telescope capable of providing a field of view of at least 2° best frames the apparent stellar gathering.

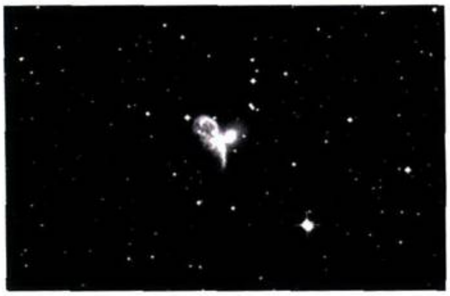
Pan 1.5° southeast of Melotte 227 to find the spiral galaxy **NGC 6920**. Viewed



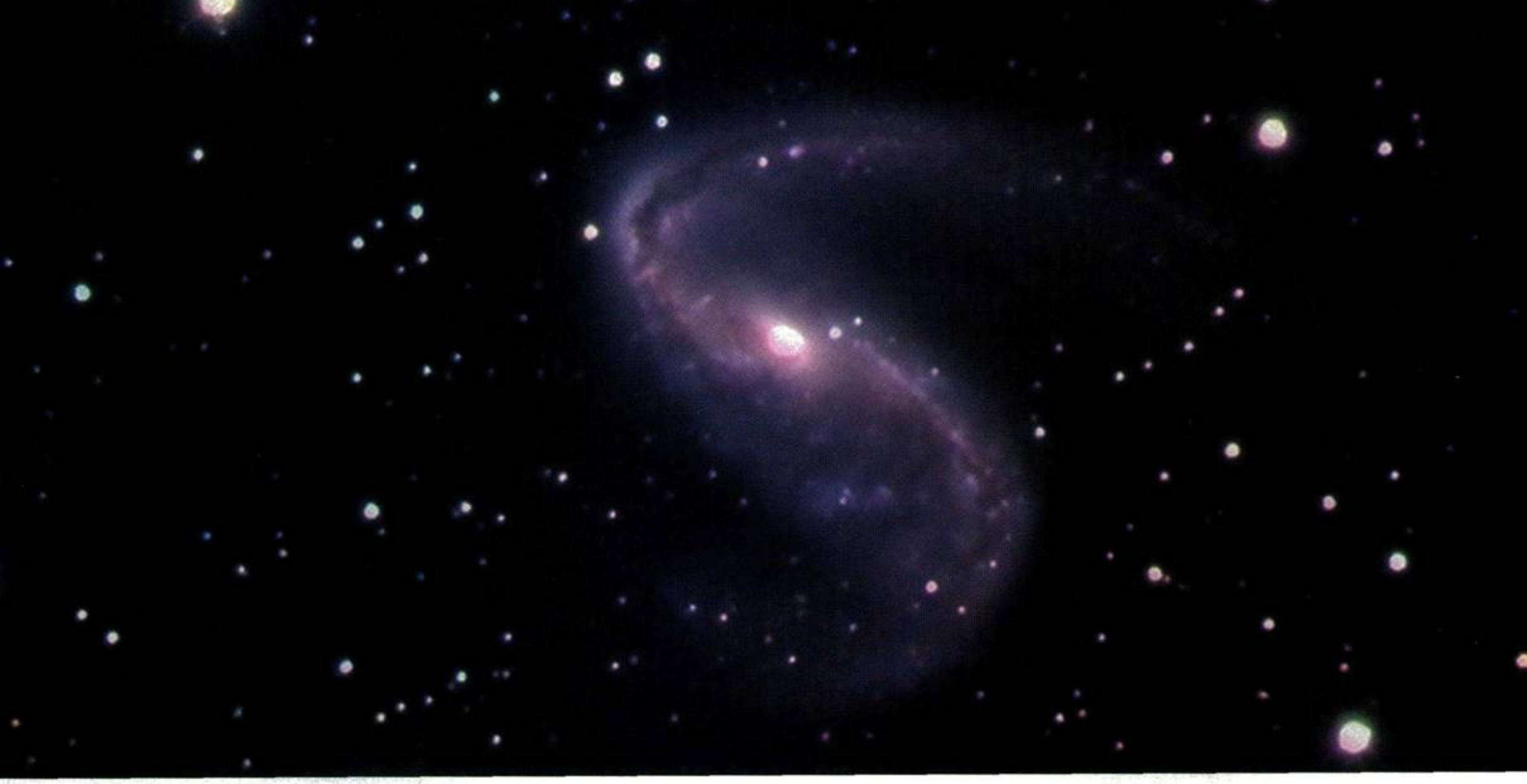
NGC 7098 shows no sign of any interaction with other galaxies in its past. It resides 110 million light-years from Earth. POSS/DSS



NGC 7637 is a faint, circular spiral galaxy located 170 million light-years away. Another faint galaxy appears to the northwest of it. DIGITIZED SKY SURVEY



NGC 6438 appears as a faint, circular halo in large telescopes. The galaxy is accompanied by the irregular galaxy NGC 6438A. DIGITIZED SKY SURVEY



NGC 2442 earned its "Meat Hook Galaxy" nickname from the two sharply curled arms that extend from the spiral galaxy's long bar. STEVEN JUCHNOWSKI

from a distance of 130 million light-years, detail is fleeting. Expect to see only a circular haze 1' across with a strongly concentrated center.

Until recently, some confusion existed as to the identity of **NGC 7095**. But thanks to some sleuthing by astronomer Harold Corwin, Jr., we now know the galaxy is the same as the one cataloged as ESO 27–1. Like most galaxies in this part of the sky, it is more than 100 million light-years away. Characteristic of type Sc spirals, it has a small core and well-defined arms. A large light bucket begins to present mottling in the halo. A pair of 12th-magnitude stars appears in the field 5' west-southwest of the galaxy's core.

Follow an imaginary line through the 5th-magnitude stars Gamma^3 (γ^3) and Gamma^1 Octantis in the direction of Beta Octantis to find **NGC 7637**. Through a 10-inch scope, the galaxy appears faint, circular, and 2' across, showing a slight central concentration. A 13th-magnitude star lies in front of the northern edge of the galaxy. A faint galaxy 2' to the northwest forms a physical pair with NGC 7637. At the galaxies' distance of 170 million light-years, their projected separation translates to 100,000 light-years, slightly less than the separation between the Milky Way and the Magellanic Clouds.

NGC 6438 is the brightest member of a tight galaxy trio. At high magnifications in a large telescope, it looks like a faint, circular halo with a very bright center. Just to the southeast, the irregular 2' by 1' oval form of NGC 6438A appears to be in contact with its brighter neighbor. The third galaxy in the system blends continuously with NGC 6438A. NGC 6438 is an early-type S0 galaxy merging with two disk galaxies. This presents the uncommon situation of merging galaxies of mixed types.

As we move into Chamaeleon, we find one of the highlights of the south polar region: the planetary nebula **NGC 3195**. The planetary's high surface brightness encourages high magnification. Use at least 200x on the 40" disk to show a slight, north-south elongation and subtle enhancements along the minor axis. The central star is listed as magnitude 15.3, but it's difficult to see in any aperture due to the nebula's brightness.

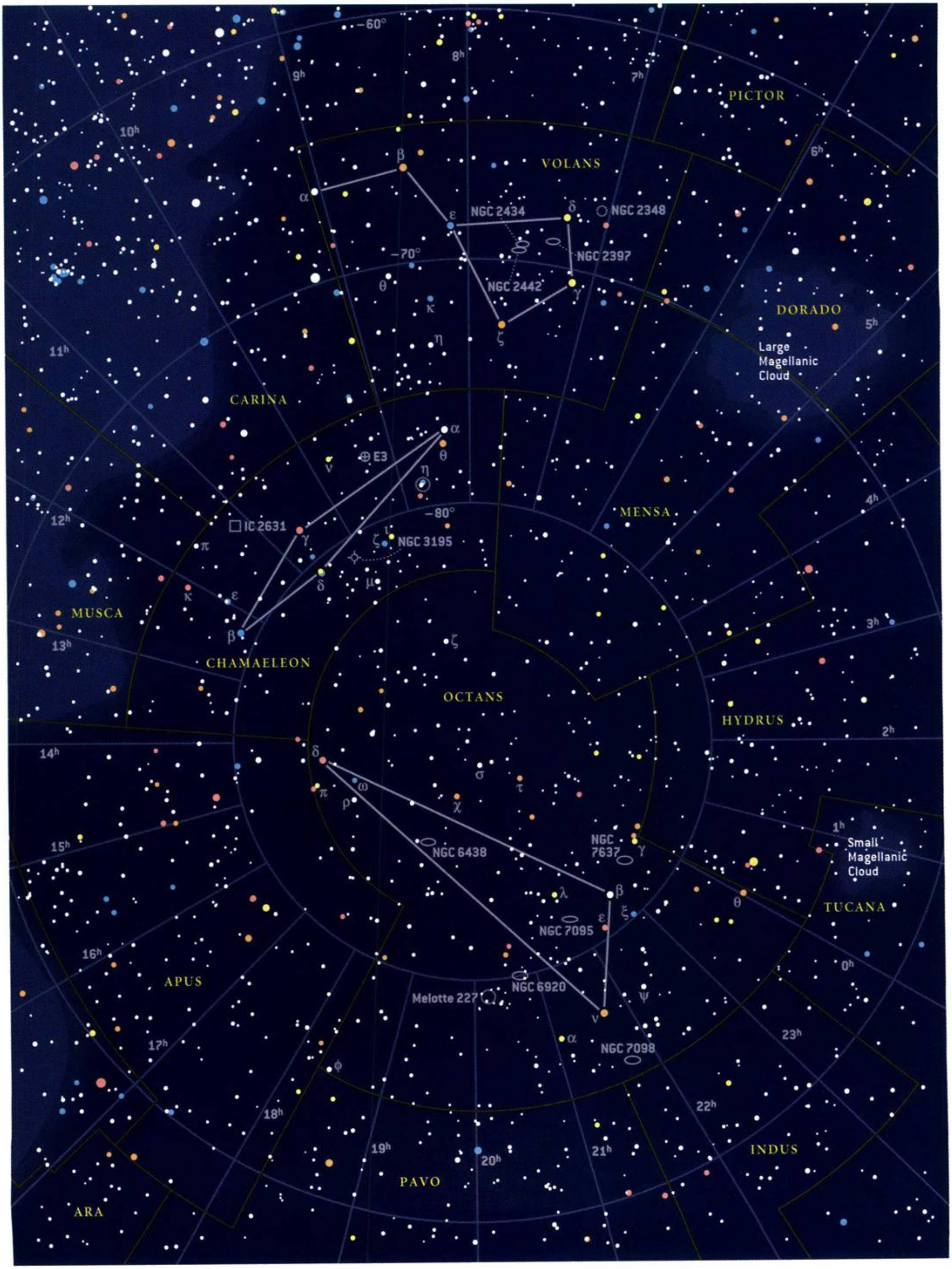
On the steadiest nights, a large telescope may be able to split **Epsilon (ε) Chamaeleontis.** The binary star's separation has decreased from 1.7" in 1835, when it was found to be a double, to a

/// THE FLYING FISH

Out where the sky and the sky-blue sea
Merge in a mist of sheen,
There started a vision of silver things,
A leap and a quiver, a flash of wings
The sky and the sea between.
Flying Fish, *Mary McNeil Fenollosa (1865 – 1954)*

Fish that leap out of the water and fly through the air apparently created such an amazing and memorable sight that Dutch navigators Pieter Dirkszoon Keyser and Frederick de Houtman immortalized these curious creatures among the stars. Originally called Piscis Volans, the Flying Fish are among several constellations named by the adventurous pair during a voyage to the East Indies in the late 16th century. The constellation first appeared on a globe created by fellow Dutchman Petrus Plancius and was included in Johann Bayer's 1603 atlas, *Uranometria*.

Volans initially accompanied Argo Navis the Ship, a celestial representation of the vessel that carried Jason and the Argonauts in their search for the Golden Fleece. However, in the mid-1700s, Abbe Nicholas de Lacaille split the large constellation into four smaller ones (Vela the Sails, Pyxis the Compass, Puppis the Stern, and Carina the Keel). Volans lies closest to Carina. — *Vanessa Thomas*


-60°
8h
9h
7h
PICTOR
10h
6h
VOLANS
β
α
ε
NGC 2434
δ
NGC 2348
NGC 2397
-70°
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NGC 2442
γ
κ
ζ
DORADO
5h
η
Large Magellanic Cloud
11h
CARINA
α
θ
η
ν
E3
-80°
MENSA
4h
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OCTANS
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NGC 7637
γ
1h
Small Magellanic Cloud
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TUCANA
NGC 7095
16h
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NGC 6920
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PAVO
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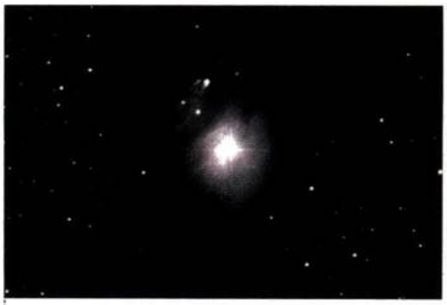
current value of 0.4". As recently as 1975, when the components were separated by 0.9", it was an easy split for an 8-inch.

Well away from the plane of the Milky Way sits the bright reflection nebula **IC 2631**. It resides on the northern end of the Chamaeleon I Dark Cloud, an active stellar nursery similar to the Rho (ρ) Ophiuchi nebula. Through an 8-inch telescope, IC 2631 appears as a bright mist 2' in diameter surrounding a 9th-magnitude star. Using low magnification, the elongated, starless void of the associated dark cloud can be traced to the south.

The inner-halo globular cluster **E3** was first spotted on an ESO blue survey plate in 1976. Despite how recently it was discovered, it is not too difficult for visual observers to see under dark skies. A moderate telescope will show a dozen or so very faint stars crowded into a 2' area. Don't expect to see an associated haze of unresolved stars, as it looks more like a loose open cluster. A distance of 25,000 light-years separates E3 from Earth.

While not an appealing telescopic object, the **Eta (η) Chamaeleontis Cluster** is worth mentioning for its very recent discovery. The thirteen stars lying within a half degree of each other were just recognized as an open cluster in 1999. The cluster's distance is only 315 light-years, making it one of the five closest open clusters to us. The cluster members are rare, nearby examples of pre-main sequence stars, seen during that brief period in their lives when they have not yet begun to burn hydrogen fuel. Visually, the brightest stars of the cluster are Eta Chamaeleontis and its two companion stars 5' to the south, all easy binocular targets.



IC 2631 shows up as a bright nebulosity on the northern edge of the Chamaeleon I Dark Cloud.
POSS/DSS

NGC 2434 looks like a circular halo with a bright center. The elliptical galaxy lies near NGC 2442.
DIGITIZED SKY SURVEY

Gamma Volantis is one of the bright stars that comprise Volans. Using a small telescope at a magnification greater than 40x reveals Gamma Volantis as a wide double star. The white glow of the 4th-magnitude primary is offset by the yellowish hue of its 6th-magnitude companion. The double-star system lies 140 light-years from us.

Move the telescope 2.5° to the east-northeast of Gamma Volantis to find the barred spiral galaxy **NGC 2442**, nicknamed the "Meat Hook Galaxy." In a 10-inch scope, it shows symmetrical hooks curving from a 4'-long bar. Except for its intense core, the body of the galaxy has a uniform brightness. It is 50 million light-years away and has eight neighboring galaxies with similar redshifts. Its distorted form presents plenty of evidence of past interaction with other galaxies.

In the same field, a quarter degree to the north-northwest, you'll find one of NGC 2442's companions. **NGC 2434** is an elliptical galaxy separated from NGC 2442 by 275,000 light-years. There isn't much detail in this bright galaxy — only a 1' circular halo with a much brighter center. Due to Volans's proximity to the Milky Way's plane, the stars are denser here than in our two previous constellations.

The barred spiral galaxy **NGC 2397** also belongs to the NGC 2442 group. It is a moderately bright oval, 2' by 1' in p.a. 120° with a slightly brighter and broadly concentrated center. More than a million light-years separate it from NGC 2442, and the two show no sign of interacting.

Like Melotte 227, **NGC 2348** is another group of stars whose status as a true open cluster can be debated. Compared to adjacent fields, star counts here are just enough to warrant open cluster status, but the stars' proper motions still have to be measured. Look for a couple dozen stars ranging from 10th to 14th magnitude over an area 10' in diameter. ■

/// Deep-sky objects in Octans, Chamaeleon, and Volans

OBJECT	R. A.	DEC.	MAG.	SIZE/SEP.	TYPE	NOTES
NGC 2348	7h03.0m	–67°24'	—	11'	OC	—
Gamma Volantis	7h08.8m	–70°30'	3.8/5.7	13.6'	Dbl	—
NGC 2397	7h21.3m	–69°00'	12.0	2.5' by 1.2'	Gal	SB(s)b
NGC 2434	7h34.9m	–69°17'	11.5	2.5' by 2.2'	Gal	E0–1
NGC 2442	7h36.4m	–69°32'	10.4	5.4' by 2.6'	Gal	SAB(s)bc
Eta Chamaeleontis	8h41.3m	–78°58'	—	30'	OC	Very young cluster
E3	9h21.0m	–77°17'	11.4	—	GC	—
NGC 3195	10h09.3m	–80°52'	11.6	38"	PN	—
IC 2631	11h09.9m	–76°37'	—	5.0'	BN	—
Epsilon Chamaeleontis	11h59.6m	–78°13'	5.4/6.0	0.4"	Dbl	—
NGC 6438	18h22.3m	–85°24'	12.4	1.7' by 1.4'	Gal	Ring
Melotte 227	20h12.1m	–79°18'	5.3	50'	OC	—
NGC 6920	20h44.0m	–80°00'	12.4	1.8' by 1.5'	Gal	SA(rs)0
NGC 7098	21h44.3m	–75°07'	11.4	4.0' by 2.3'	Gal	(R)SAB(rs)a
NGC 7095	21h52.4m	–81°32'	12.2	2.8' by 2.7'	Gal	SB(s)c
NGC 7637	23h26.5m	–81°55'	12.5	2.0' by 1.8'	Gal	SA(r)c

Object: Designation in NGC or other catalog. **R. A. and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds. **Notes:** Hubble types for galaxies.

TECHNIQUES

Finding a rock from space may seem like the ultimate astronomical challenge, but collecting these otherworldly specimens is easier than you think. /// BY RAYMOND SHUBINSKI

The lure of meteorites

What drives people to spend countless hours and dollars to own a meteorite? For dealers, it's not just the profit. For private collectors, it's more than the joy of owning a piece of the solar system. For anyone who has fallen under the spell of meteorites, it's the talisman-like power of connecting with worlds and eons beyond our grasp.

Let the bidding begin

After a meteorite fell in Park Forest, Illinois earlier this year, only two weeks elapsed before pieces of this rather common, stony meteorite appeared on eBay. One 36.3-gram chunk sold for an amazing $1,750. That's more than three times the price of gold that day.

The bidding started at $50 for this cosmic rock. During the next two days, the price rose to $666. By the fourth day, it hit $912. Then the bidding became serious. On the last day, the price climbed to the final $1,750. Who would bid so hard and so much for such a small prize?

It turned out to be Ron Dilulio, a former museum and planetarium director living in Texas. Dilulio caught the bug when he developed a friendship with the late Oscar Monnig, an avid meteorite collector. Dilulio's specialty is field trips during which he captures meteorites in the "wild." Dilulio still quotes Monnig, "Your investment in these rocks may seem questionable to some folks, but when you see the glint of excitement in children's eyes when they hold one of your samples, any doubt about their value is erased." Dilulio is more than pleased with his purchase.

History

In 1922, the British archaeologist Howard Carter, asked if he could see anything as he peered through an opening into the tomb of King Tut replied, "Yes, it is wonderful." Along with the mummy of Tutankhamun, 140 priceless objects were found, including a dagger of solid gold and a dagger with an iron blade. Experts believe the iron dagger was forged from a meteorite.

Ancient people around the world valued and worshiped rocks that fell from the sky. The Romans minted coins that show what appear to be meteorites on pedestals. Some Native American burial sites contain carefully wrapped meteorites placed with the dead. A beautifully forged knife allegedly was made from a witnessed fall of an iron meteorite in India in 1621. Other cutting utensils have been made in the past using meteoritic iron. The ancients never doubted that rocks fell from the sky.

A COMET
STRIKES THE EARTH
Sparks from a Celestial Bomb
METEORITE CRATER STUDY KIT
IMPACTITE
METEORITE

FEW METEORITE-RELATED EDUCATIONAL materials have been produced over the years. One of the most popular was the Meteorite Crater Study Kit, which contained the somewhat inaccurately titled booklet, *A Comet Strikes the Earth*. ASTRONOMY: JIM FORBES

The sky is falling

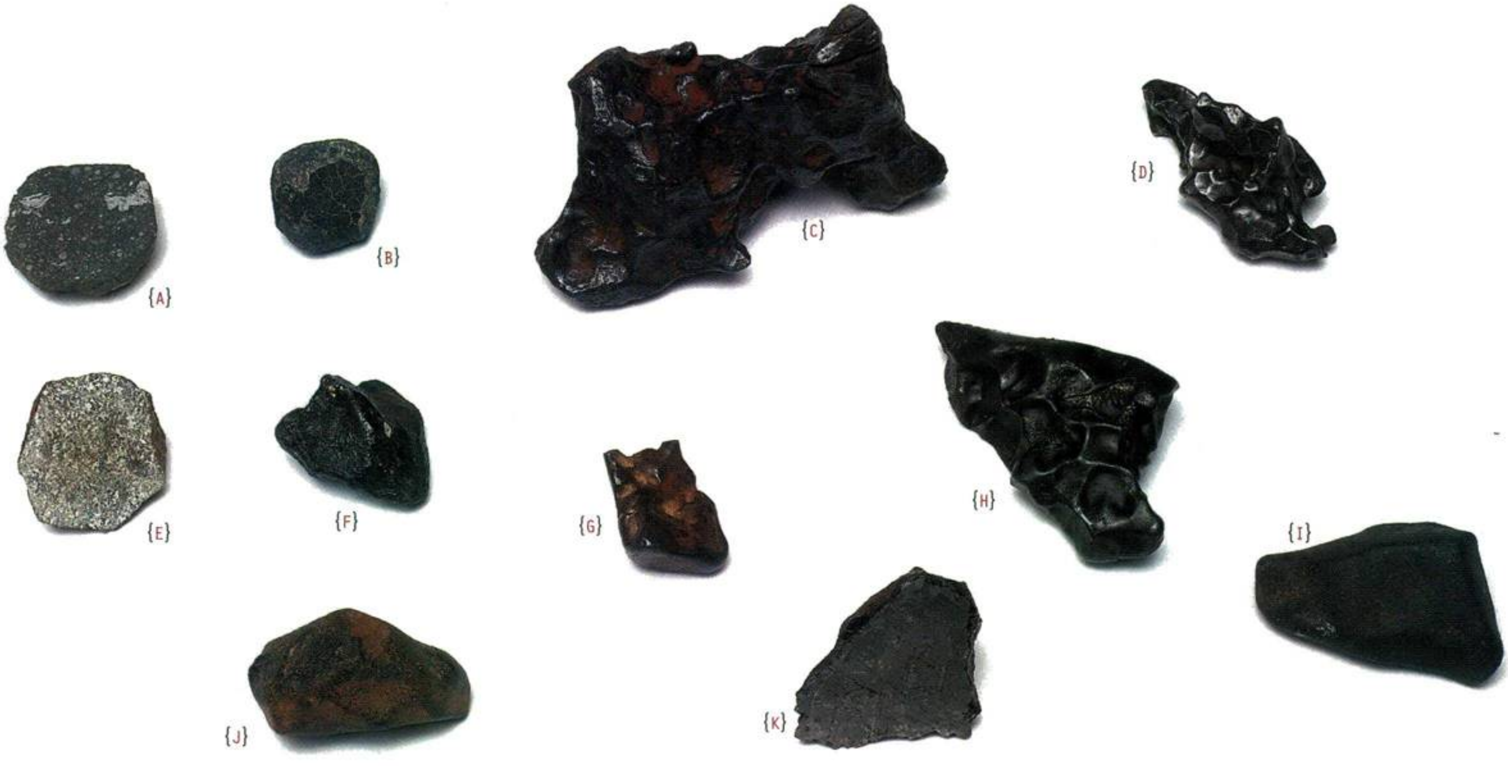
By the 18th century, the savants of Europe had concluded that such an idea was nonsense. An educated person would know that stones from heaven were mere folklore. Even though a well-documented fall occurred in the city of Ensisheim, Germany, during the same year Columbus sailed to the New World, doubt remained.

In 1803, the village of l'Aigle, France, was peppered with a fall of meteorites that

THE YEAR WAS 1931, and the country was sliding into depression. H. H. Nininger and his family were struggling like other Americans. "There were periods when the purchase of a pair of children's shoes was an occasion for a family conference," Nininger wrote. Yet, through an almost evangelical effort in small communities throughout the Midwest, Nininger amassed a private collection of meteorites and advanced the science of meteoritics.

IN 1990, Robert Haag of Tucson, Arizona, encountered the full force of the Argentine police while trying to truck a 37-ton meteorite out of the country. Haag purchased the space rock from a farmer only to have it confiscated at the border. The media coverage of this incident ultimately brought about the recovery of the most beautiful stony-iron meteorite ever seen, the Esquel pallasite. "You never know where the adventure will lead you," Haag says.

ON MARCH 26, 2003, the midnight sky lit up over the Midwest and south Chicago experienced a rain of stony meteorites that left local residents fearing an attack. Within days, Steve Arnold had left his home in Kingston, Arkansas, made the nearly 700 mile trip to Chicago, and was riding a bicycle around Park Forest, Illinois, with a magnet taped to the end of a stick, picking up the invaders. His search netted several nice specimens.



DIFFERENT TYPES OF METEORITES from the author's collection include the Allende, Mexico meteorite, which fell at 1:05 A.M. on February 8, 1969. Tests by meteorite experts concluded that the parent body of the Allende meteorite formed approximately 100,000 years before Earth did. These examples are a cut and polished piece (A) and a whole stone (B), which shows fusion crust, the burnt outer layer of the meteorite caused by its fiery plunge through the atmosphere. **IRON METEORITES** are the ones most often found on Earth. They resist weathering better than stony meteorites and tend to stand out more from rocky terrain. The Canyon Diablo (C), Sikhote Alin (D and H), Taza (G), and Toluca (K) iron meteorites are shown here. **STONY METEORITES** are several times more common than iron meteorites, but they don't stand up to weathering as well, so they're not found as often. In fact, the majority of stony meteorites are found from witnessed falls. Stony meteorites shown here are cut and polished (E) and whole stone (J) pieces of the Millbillillie, Australia, meteorite, the Camel Donga, Australia, stone (F), showing a beautiful fusion crust, and the Chiang Khan stone (I) from Thailand. *ASTRONOMY:* JIM FORBES

made scientists take note. On December 14, 1807, Weston, Connecticut also was showered. Scientists from Yale University collected these stones. The emerging science of "meteoritics" was taking on respectability.

As institutions such as Yale, the Smithsonian, and other major museums began to take interest in these "thunderstones," so did private collectors. The famous German philosopher Goethe acquired a chunk of the Ensisheim meteorite that remained on his desk until his death. Other natural philosophers also were eager to add these rocks to their "cabinets of curiosities."

Types of space rocks

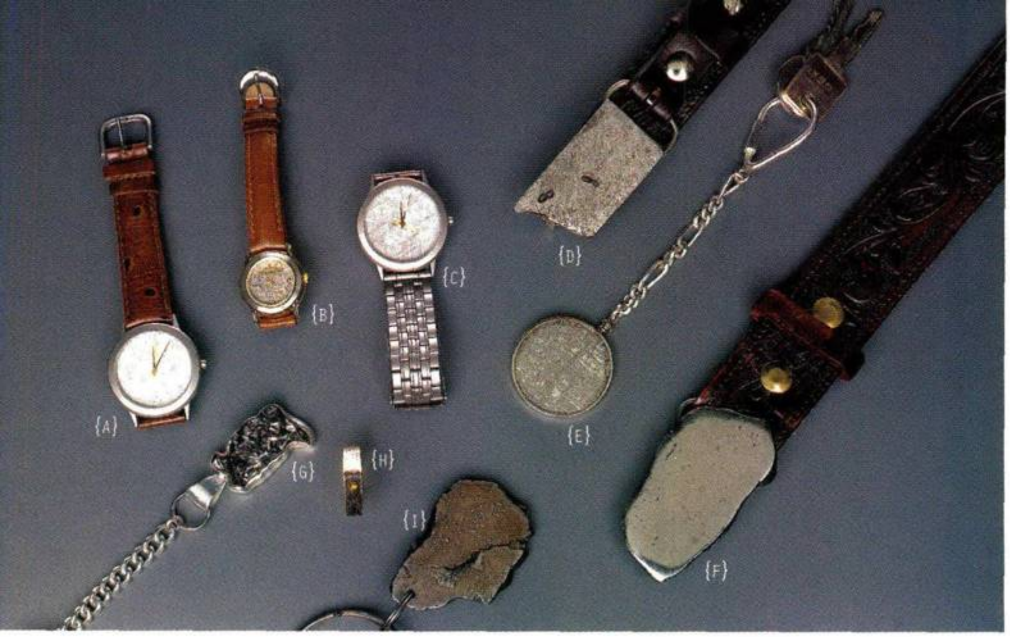
Scientists soon recognized that this space debris came in three major types: iron, which is composed of approximately 92 percent iron and 8 percent nickel; stony-iron, a blend of iron and magnesium-rich olivine; and stony, which has only a small amount of iron content. Anyone who has seen a display of meteorites can spot the iron variety. Because of cost and availability, this is the type most beginning collectors purchase first.

Museums tend to showcase irons. As a result, a misconception exists that they are the most common type to strike Earth. In reality, stony meteorites represent about 80 percent of all falls. Irons represent less than 20 percent and stony-irons far less than 5 percent. In the field, however, irons represent more than 90 percent of all finds for several reasons. Irons hold up better to weathering, and also, they are relatively easy to find with metal detectors.

Pallasites, a stony-iron meteorite class of which the Esquel (Argentina) is the prime example, are one of the rarest and most beautiful of all meteorites. Cut into a thin slice, light can pass through the green-gold olivine as if it were a stained-glass window.

NWA 032, 31.9mg
Lunar Mare Basalt

LUNAR AND MARTIAN METEORITES are extremely rare, but some do find their way into the hands of collectors. The Zagami meteorite (bottom), which originated on Mars, fell to Earth on October 3, 1962. *ASTRONOMY:* JIM FORBES



FASHION ACCESSORIES MADE OF METEORITES highlight the wardrobes of meteorite collectors.

A) Man's wristwatch with Gibeon meteorite dial
B) Woman's wristwatch with Gibeon meteorite dial
C) Man's wristwatch with Gibeon meteorite dial and titanium band
D) Belt buckle made from Gibeon meteorite
E) Key ring with etched Gibeon "silver dollar"
F) Belt buckle made from Canyon Diablo (Arizona) meteorite
G) Key fob made from Sikhote Alin (Russia) meteorite
H) Man's 18K gold ring with Nuevo Mercurio (Mexico) meteorite inlay and Esquel pallasite cabochon
I) Key fob made from Toluca (Mexico) meteorite

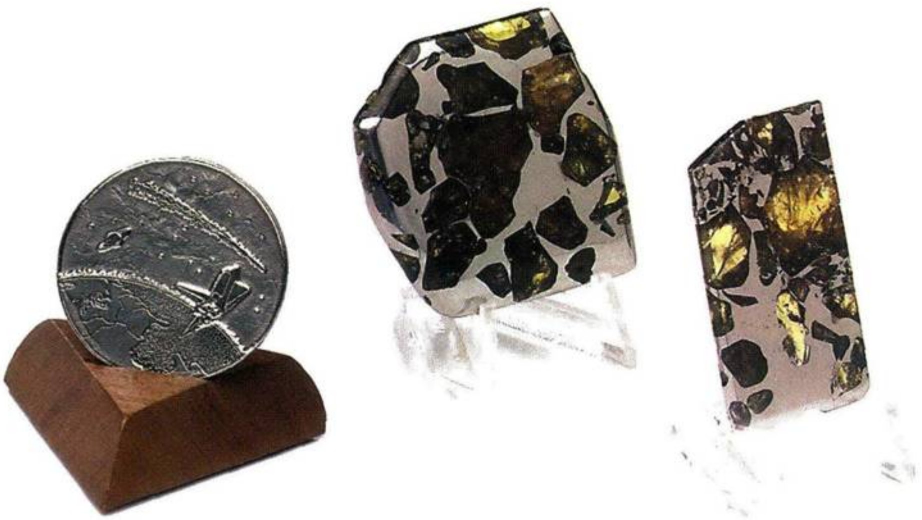
ASTRONOMY: JIM FORBES

This meteorite type is a benchmark of many collections. It too has been formed into stunning jewelry.

Where on Earth?

What should a person collect and how are these space rocks obtained? As with all classification systems, the three major types mentioned have a number of subcategories. The field of meteorite study can become a quagmire of terms and listings quickly. Before acquiring anything, the potential collector should read one of the new books on meteorites (see Resources, page 114). The next question is: Will the collection represent a single category or all three categories? Finally, where are meteorites obtained?

Most of us can't spend our vacations walking the Sahara with nomads, braving the altitudes of the Chilean Andes with metal detectors, or roaming the American Southwest looking for meteorites. A few folks do just that, however, and some make their living by selling the rocks they find. To build a collection, most of us turn to these purveyors of cosmic debris. A good deal of the fun of collecting meteorites is getting to know these people.



THIS MEDALLION, (left) commemorating both the most recent approach to Earth by Halley's Comet and the demise of space shuttle Challenger, is made from a piece of the meteorite that created *Meteor Crater near Winslow, Arizona.* Due to the extremely high smelting temperature of this iron, the furnace failed before the full production run could be completed. As a result, fewer than one hundred of these medallions were made. Pallasites are stony-iron meteorites believed to originate in a boundary layer between the mantle and core of an asteroid. The metal is iron and the mineral is olivine, which is nicely translucent in cut and polished specimens. The Imilac pallasite (center) was discovered in 1822 in Chile's Atacama Desert, and the Esquel pallasite (right), discovered in 1951, comes from Esquel, Chubut, Argentina. ASTRONOMY: JIM FORBES

If an expedition isn't in the cards, the next best thing is a major gem and mineral show. The most famous of these shows is held every February in Tucson, Arizona. There are shows in major cities across the country also, which many meteorite dealers attend. No substitute exists for meeting the dealers. There's also no substitute for holding a specimen in your hand before the money leaves your wallet.

Cash or charge?

The first reaction when buying a meteorite will be sticker shock. With few exceptions, these rocks are sold by the gram, not by the pound. If your dream is to have a 500-pound iron doorstop, sell the car *and* house first. Irons sell from a dollar per gram and higher depending on the piece. Stony meteorites sell for more than twice the price of irons. The exotic stony-irons start around $10 a gram, and yes, it goes up from there. A piece of the Allende carbonaceous chondrite starts near $15 a gram, while the Zagami Mars meteorite can cost $1,000 a gram. The well-heeled collector can own even a small chip of lunar meteorite (please call for prices).

Space rocks on-line

If you can't attend the shows, there are catalogs both in print and on-line. A number of dealers have outstanding web sites that

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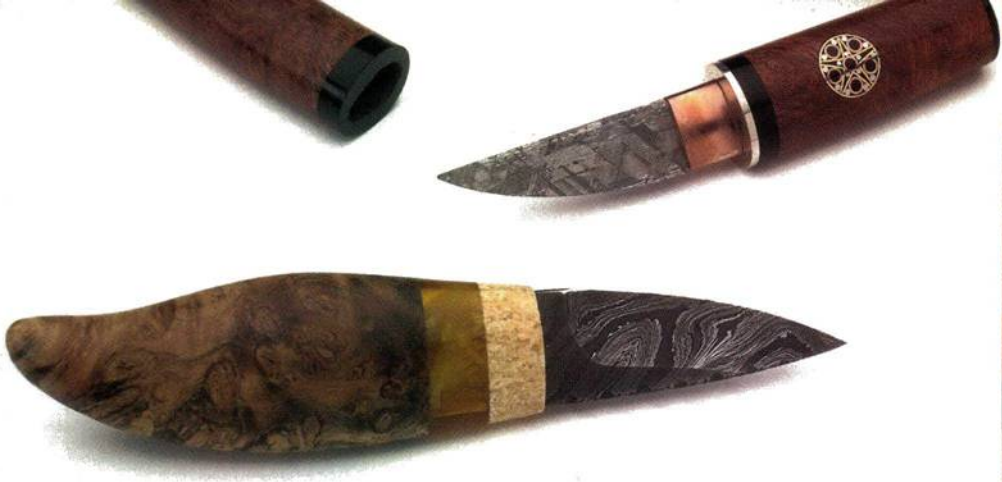
Raymond Shubinski *is director of the East Kentucky Science Center in Prestonsburg, Kentucky, and an avid meteorite collector.*



KNIVES WITH METEORITE BLADES are uncommon. First, meteoritic material is rather scarce. Second, a high degree of craftsmanship is required to shape the iron. (Impurities make meteoritic iron notoriously difficult to work with.) The blade for the tanto-style knife (top, with sheath) was cut from a slab of Gibeon iron meteorite, polished, and then etched. A different technique called the Damascus method was used on the larger blade (bottom). The Damascus method involves heating the meteoritic iron red hot and repeatedly folding it over on itself to produce layers of iron — and a much more durable blade. ASTRONOMY: JIM FORBES

A HEAVENLY EVENT deserves heavenly stones. Both bands for the wedding of Jennifer Shubinski and Patrick McDonnell are made of 14K gold and iron from the Gibeon meteorite. RAY SHUBINSKI

not only sell but also educate; www.meteoritemarket.com is an excellent example. You can browse the offerings and receive a celestial education at the same time. Other dealers have sites that help buyers learn the ropes as well as add to their collections. In many ways, these dealers are carrying on the educational mission started by H. H. Nininger more than half a century ago.

Then there's eBay. *Caveat emptor* (buyer beware). The listings for meteorites on eBay are legion. At times, the bidding can drive the price of a particular specimen far beyond what is reasonable. There are deals on eBay, but know what you're buying, and check current prices before bidding.

Interesting, related items also pop up when you search for "meteorites." If you use your collection for education, pick up a piece of native Earth iron. Also, meteorite jewelry and knives often appear.

By the mid-1980s, large quantities of the Gibeon meteorite were being exported from Africa. The Gibeon has one of the most beautiful Widmanstätten figures (crystal patterns that appear when an iron meteorite is etched with a mild acid) of any iron meteorite. Its high nickel content also makes it very malleable. This meteorite has been forged into daggers, made into beads and jewelry, and even fashioned into guitar picks.

Heavenly stones

In Harvey H. Nininger's autobiography, *Find A Falling Star*, he says, "[Meteorites] represent other parts of the universe about which we as yet have no way of learning save as we study the light that arrives from luminous sources . . . The lumps of stone and iron still are our most tangible source of information concerning the vastness of space stretching immeasurably in all directions." Nininger wrote those words in 1972, and they still ring true today. To find a fallen star is to touch a bit of heaven. ■

To learn more about meteorites, visit www.astronomy.com/toc

/// METEORITE HUNTERS

A VISIT TO TERRY AND SUSAN BOSWELL'S SHOP, Joshua Tree Imports in Lakeville, Indiana, is an exotic experience. Huge fossils are propped up along the wall, dinosaur bones are laid out for inspection, and cases of meteorites are full of treasures. Terry explains, "I started looking for meteorites as something to do on trips out West to gem and mineral shows." It's obvious that Terry's interest has gone far beyond this when he shows pictures of tribal nomads he's met in the Sahara Desert. It was Terry who first brought the beautiful Taza iron meteorite out of Morocco.

TERRY BOSWELL

ROBERT HAAG has flown ultralight planes across the Australian Outback in search of meteorites. He has been featured in *National Geographic* and has been a guest on a Japanese game show. Haag also has been thrown in jail — all because of hunting meteorites. Haag is one of the few individuals to have discovered his own lunar meteorite. The pursuit of these space rocks can lead in strange directions.

ROBERT HAAG

THE SEARCH FOR METEORITES can lead to pure excitement, too. Steve Arnold returned several times to Park Forest, Illinois, after the March 2003 fall. On one occasion while searching with his daughter Kelsey, both with magnet sticks in hand, a father and son playing ball asked what they were doing. Steve gave the man a flyer describing meteorites and explained the recent fall. Steve and his daughter moved on only to have the pair bike up breathlessly a few minutes later with a meteorite! They found the stone right in the yard where they were playing ball. Steve weighed the stone and gave them information on the 10-gram meteorite. The father and son now have a treasure and a memory to share because of a guy with a stick and a magnet.

STEVE ARNOLD

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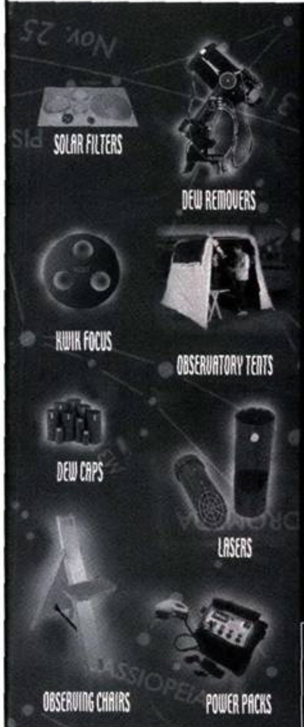

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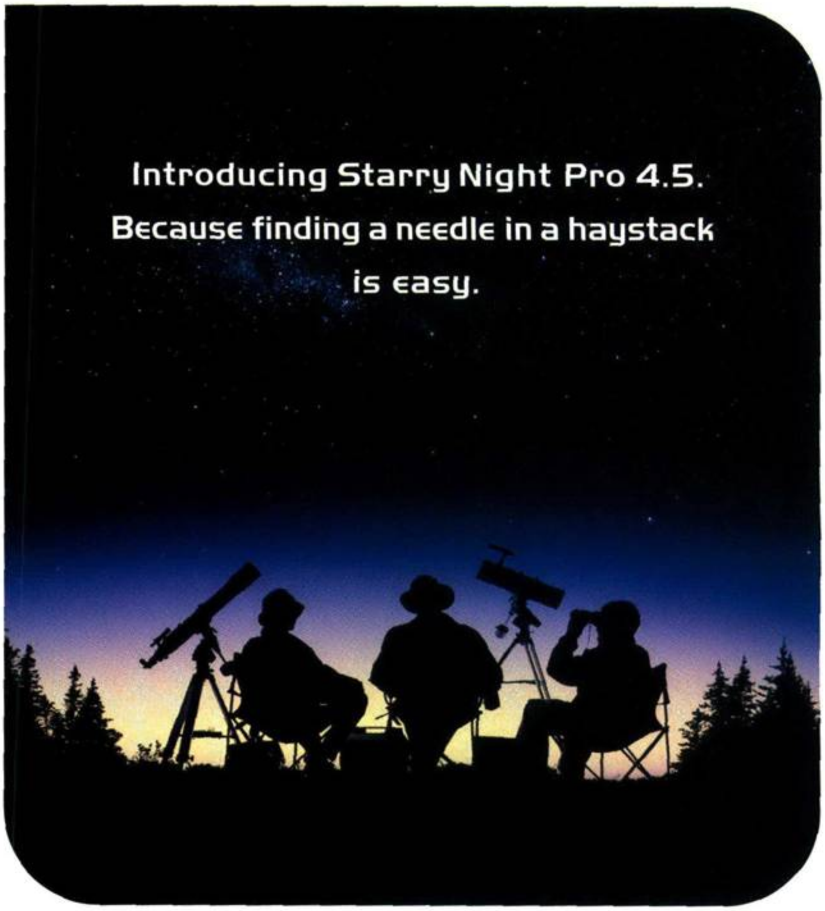
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TECHNIQUES

A longtime collector shares his secrets for choosing and finding the best astronomy books.

/// BY MICHAEL E. BAKICH

Build an astro library

For a hobby populated largely by gearheads, it might be surprising that one of the most popular accessories in amateur astronomy is low-tech: books. In every recent survey, *Astronomy* subscribers listed reading second only to observing as their leisure activity of choice. Sky-gazers purchase lots of books. But which books are best? Where do you find them? What categories should you collect? Over the years, I've amassed thousands of titles; some help me observe better, others help me understand what I'm observing. Here are a few suggestions for building your own astronomical library. Because some of the books below are out of print, check for them in used bookstores or on web sites such as www.bookfinder.com.

Survey yourself

Start with what interests you. This may sound simplistic, but unless your shelf space and bank account are limitless, you'll probably have to build your library slowly. So begin with titles that match your interests. For example, if your first love is astrophotography, look for a copy of Jean Dragesco's classic *High Resolution Astrophotography* (Cambridge University Press, New York, 1995).

Buy the best books you can afford, but don't get hung up on first editions unless you're building a collector's library. Later editions generally will contain more material and will be more factually accurate. For used titles, consider the book's overall condition. Are all the pages intact? Is the binding secure? How does the cover look? Obviously, if you decide to sell the book someday, you'll get a higher price for it if it's in good condition.

How many books should you aim to collect? That depends on your desires and resources, but an acquisition schedule is probably a good idea. When I first started collecting, I resolved to purchase one new title a month. After collecting for several years, I noticed I was buying more than my stated goal, probably a book every two weeks. Today, I average a new astronomy book each week. If you do this for several years, you'll be amazed at the number of books you'll amass.

Start and stay organized

About 15 years ago, I called my friend Ray who lived a couple of states away to ask if he had a certain book. Ray instructed me to go into my living room and look in the middle of the third shelf of the bookcase closest to the front door. I was incredulous when I discovered the very book I'd called about. The fact that someone knew my books better than I did so shocked me that I resolved to organize my collection.

I now have a detailed inventory, sortable by each book's author, title, date of publication, or subject. In the spirit of redundancy, I keep the database saved on my computer, printed in hardcopy form, and stored in my PalmPilot (the latter is especially handy in bookstores). Last but

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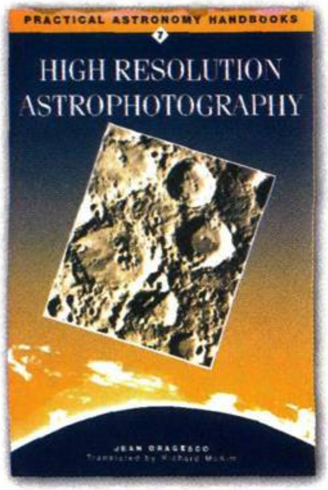
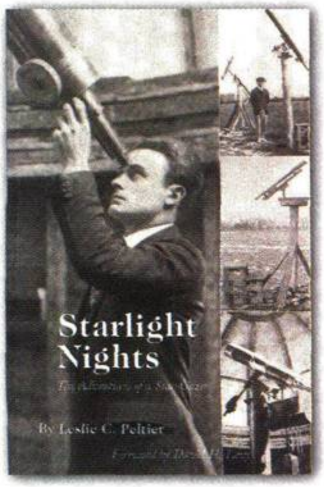
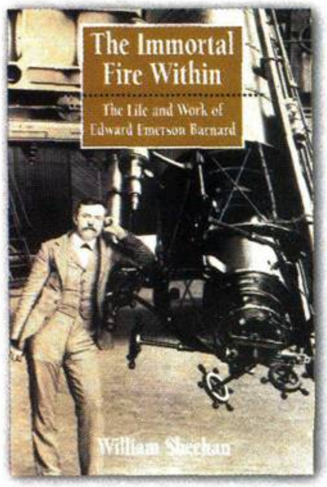
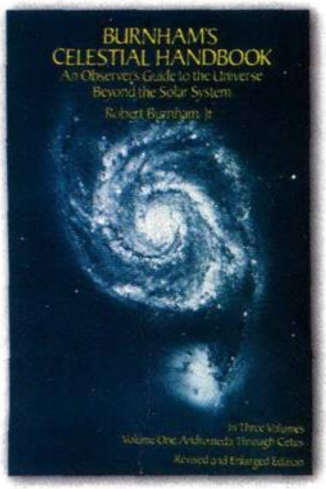
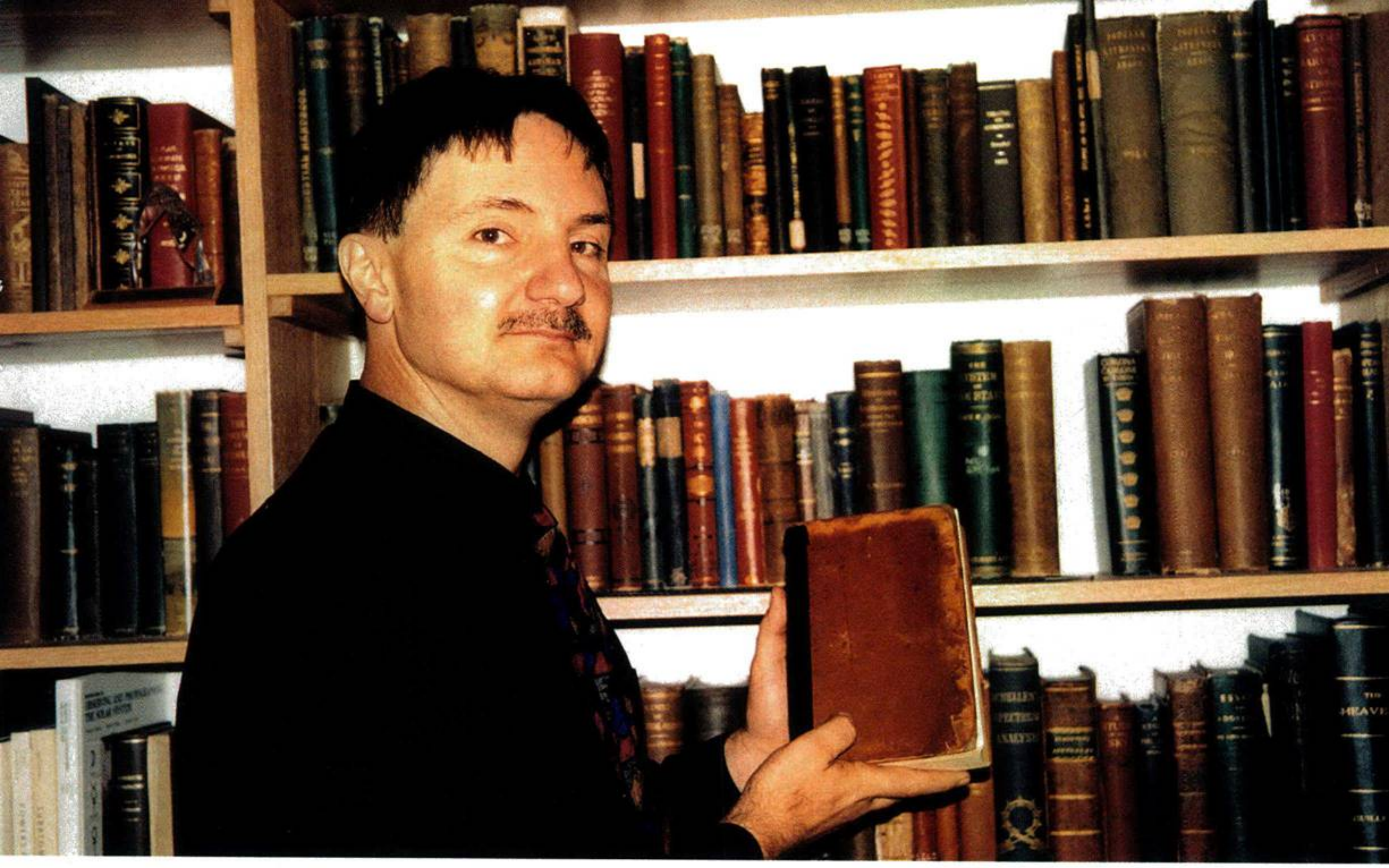
Michael E. Bakich *is an associate editor of* Astronomy *and an avid book collector. Over the last 25 years, he has amassed about 3,000 astronomy titles.*


PRACTICAL ASTRONOMY HANDBOOKS
7
HIGH RESOLUTION ASTROPHOTOGRAPHY
JEAN DRAGESCO
Translated by Richard McKim


Starlight Nights
The Adventures of a Star-Gazer
By Leslie C. Peltier


The Immortal Fire Within
The Life and Work of Edward Emerson Barnard
William Sheehan


BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham Jr
In Three Volumes
Volume One: Andromeda Through Cetus
Revised and Enlarged Edition



A TRUE COLLECTOR, Michael Bakich proudly displays his first-edition copy of Mary Somerville's *Mechanism of the Heavens*, purchased for $9.98. JEFF MEDKEFF

not least, I keep a hardcopy off-site — at Ray's, of course.

Shop till you drop

Support your local bookstores. It won't take long to memorize their layouts: The important areas are the science section, order desk, and — for caffeine junkies — the coffee bar. Used bookstores are great for locating out-of-print, classic titles. Once the owner recognizes you as a returning customer, he or she is more likely to purchase astronomy books and to let you know when they arrive.

But if bookstores aren't your bag, today you can build a library without leaving your house. While you can't see or handle the book yourself, Internet sites often carry more titles and offer better bargains than stores. Weigh shipping costs against any Internet discounts; I've found that if a book is valued at more than $25, it's usually cheaper to acquire on-line. But Internet buyers beware: Even though web sites usually describe the condition of used titles in detail, it's still a good idea to purchase only from sites that offer money-back guarantees.

Recommendations

If you're like me, you (quite unrealistically) desire *all* astronomy books, but certain books stand out as "must haves." In this article, I include a few titles that fall within some of the more popular astronomy categories: star atlases, observing guides, and books about cosmology.

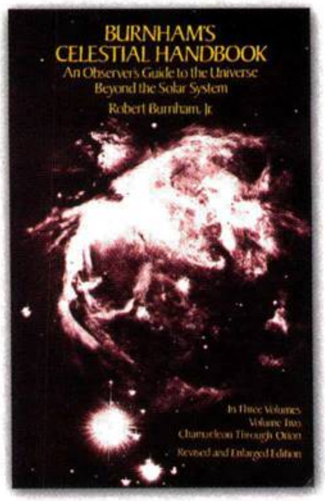
Starting on the non-technical side, I strongly recommend two biographies. Actually, the first is an autobiography and necessary reading for amateurs. *Starlight Nights: The Adventures of a Star-Gazer* by Leslie C. Peltier (Sky Publishing, Cambridge, Massachusetts, 1999) is an inspirational account of the lifelong journey of an amateur astronomer. The other is *The Immortal Fire Within: The Life and Work of Edward Emerson Barnard* by William Sheehan (Cambridge University Press, New York, 1995). *Immortal Fire* highlights one of the most famous professional astronomers — and one of the greatest visual observers — who ever lived.

Sky guides

Although there is no shortage of good sky guides, only one is indispensable, and it has been around for a quarter-century: *Burnham's Celestial Handbook: An Observer's Guide to the Universe Beyond the Solar System* by Robert Burnham, Jr. (3 volumes, Dover Publications, New York, 1978). *Burnham's* truly is the bible of observing, and I say that with full knowledge of the great number of mistakes and old data found within its more than two thousand pages. This set of books simply must be on your shelves.

If you have a 10-inch or larger telescope, I highly recommend *The Night Sky Observer's Guide* by George R. Kepple and Glen W. Sanner (2 volumes, Willmann-Bell, Richmond, Virginia, 1998). It is a superb collection of celestial details seen by the authors, both of whom are top-notch observers.

The best sky guides are written by observers who live for the next clear night. Two such individuals are Christian B. Luginbuhl and Brian A. Skiff. More than a decade ago, they produced a work entitled *Observing Handbook and Catalogue of Deep-Sky Objects* (Cambridge University Press, New York, 1989). This book provides accurate data for 2,050 objects, all of


BURNHAM'S
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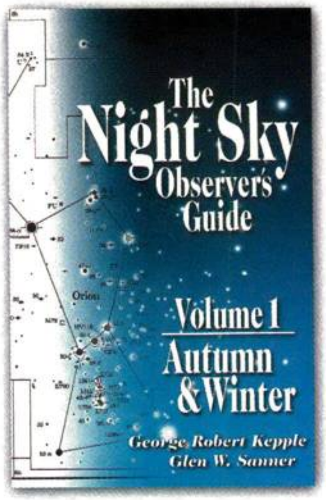
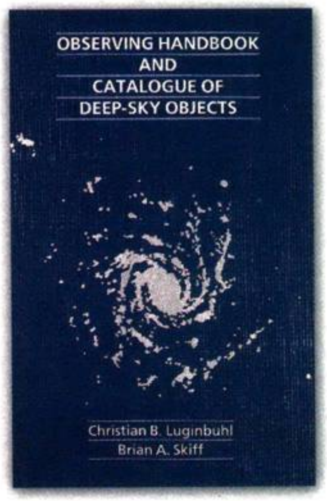
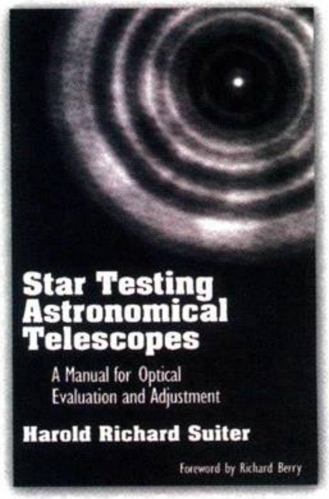
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
In Three Volumes
Volume Two
Chamaeleon Through Orion
Revised and Enlarged Edition


The Night Sky Observer's Guide
Volume 1
Autumn & Winter
George Robert Kepple
Glen W. Sanner


OBSERVING HANDBOOK AND CATALOGUE OF DEEP-SKY OBJECTS
Christian B. Luginbuhl
Brian A. Skiff


Star Testing Astronomical Telescopes
A Manual for Optical Evaluation and Adjustment
Harold Richard Suiter
Foreword by Richard Berry

which the authors observed through 6-inch and 10-inch telescopes.

Tools of the trade

Books about telescopes are not as common as one might think, probably because each scope comes with an operator's manual. An excellent book that covers many of the technical aspects associated with telescopes is Harold Richard Suiter's *Star Testing Astronomical Telescopes* (Willmann-Bell, Richmond, Virginia, 1994). Please note: This is not a book for beginners — it is for serious amateurs who want to evaluate their optical systems.

If you're relatively new to the hobby, you may not have a system to test. You may be intimidated by the choices and unsure of the equipment you need. If so, make a place on your shelves for the most recent edition of *Star Ware* by Philip S. Harrington (John Wiley & Sons, Hoboken, New Jersey, 2002), an essential guide to buying astronomical equipment.

For an historical look at telescopes and a great reference detailing how modern telescopes came to be, read *The History of the Telescope* by Henry C. King (Dover Publications, New York, 1979). This book will give you plenty of background information and makes for great reading on cloudy nights.

The solar system

So many books about the Sun, Moon, planets, comets, asteroids, and the other denizens of the solar system have been written that choosing only a few to highlight seems impossible. Certain titles do stand out, however.

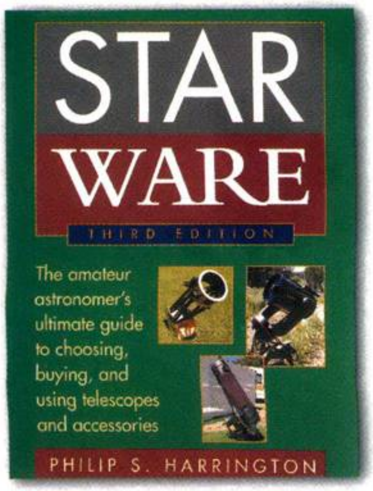
Two excellent books on our daytime star are *The Cambridge Encyclopedia of the Sun* by Kenneth R. Lang (Cambridge University Press, New York, 2001) and *Solar Astronomy Handbook* by Rainer Beck, Heinz Hilbrecht, Klaus Reinsch, and Peter Völker (Willmann-Bell, Richmond, Virginia, 1995).

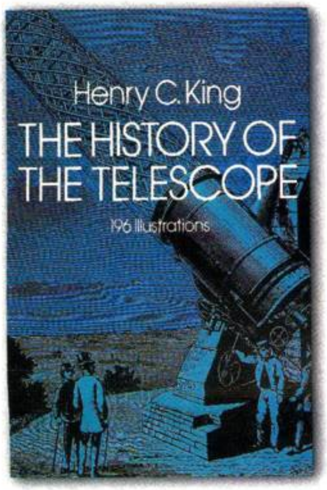
I think the best observing guide for the Moon is Antonín Rükl's *Atlas of the Moon* (Kalmbach Books, Waukesha, Wisconsin, 1990). The English translation of this book has been out of print since the year it appeared and is now hard to find.

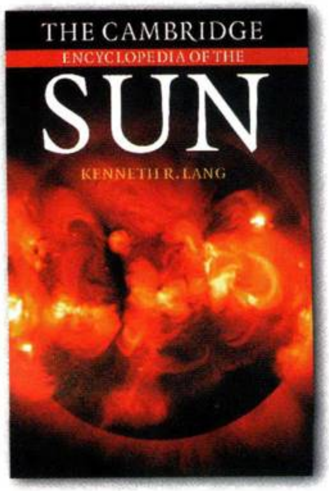
The Giant Planet Jupiter by John H. Rogers (Cambridge University Press, New York, 1995) is a profusely illustrated guide to Jupiter. My choice for Saturn is a bit more dated but contains an incredible amount of historical information: Arthur Francis O'Donel Alexander's *The Planet Saturn: A History of Observation, Theory and Discovery* (Dover Publications, New York, 1980).

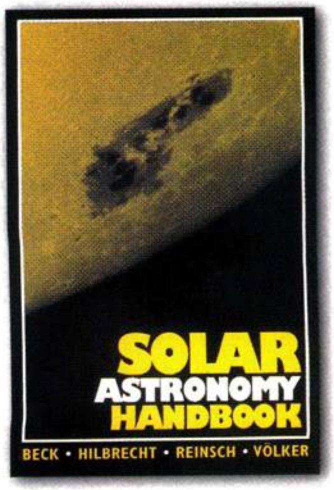
Books with a [BIG] bang

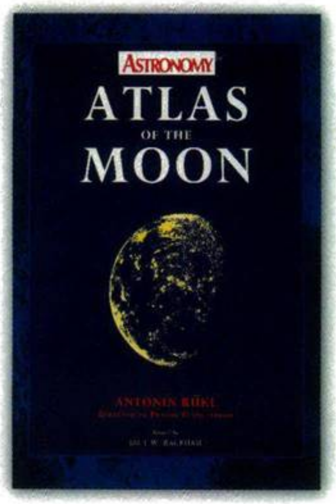
Amateur astronomers love learning about the Big Bang, the inflationary universe, dark matter, and black holes. One classic work in this genre is Stephen Hawking's *A Brief History of Time: From the Big Bang to Black Holes* (Bantam Books, New York, 1988). Published more recently, *The Whole Shebang: A State-of-the-Universe(s) Report* by Timothy Ferris (Simon & Schuster, New York, 1997) provides a good overview of the state of cosmology. Both are clearly written and relatively non-technical.

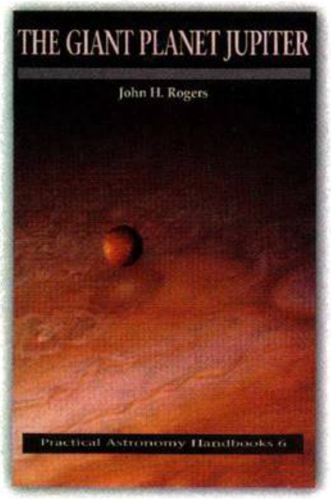

STAR WARE
THIRD EDITION
The amateur astronomer's ultimate guide to choosing, buying, and using telescopes and accessories
PHILIP S. HARRINGTON

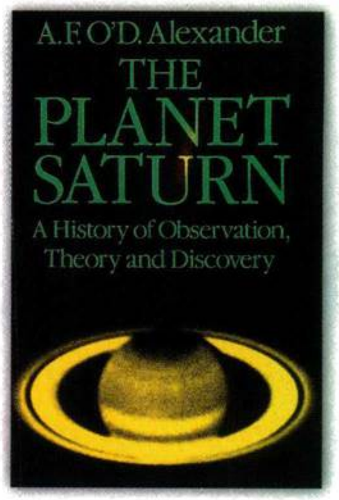

Henry C. King
THE HISTORY OF THE TELESCOPE
196 Illustrations

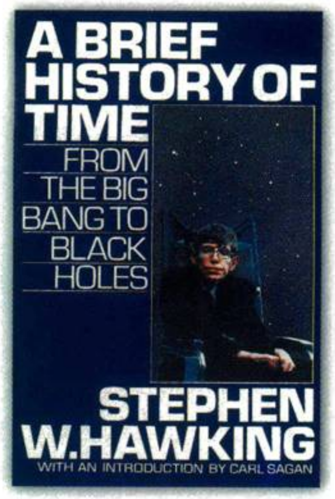

THE CAMBRIDGE
ENCYCLOPEDIA OF THE
SUN
KENNETH R. LANG


SOLAR ASTRONOMY HANDBOOK
BECK • HILBRECHT • REINSCH • VÖLKER


ASTRONOMY
ATLAS OF THE MOON
ANTONIN RÜKL


THE GIANT PLANET JUPITER
John H. Rogers
Practical Astronomy Handbooks 6


A.F. O'D. Alexander
THE PLANET SATURN
A History of Observation, Theory and Discovery


A BRIEF HISTORY OF TIME
FROM THE BIG BANG TO BLACK HOLES
STEPHEN W. HAWKING
WITH AN INTRODUCTION BY CARL SAGAN

Miscellaneous

Rather than listing more categories, I have placed a few of my favorite books into one last catchall subdivision. No better reference exists for the dates and times of astronomical phenomena than Jean Meeus's superb *Astronomical Tables of the Sun, Moon and Planets* (Willmann-Bell, Richmond, Virginia, 1995). Here you will find dates, times, distances, and angular sizes for martian oppositions through the year 3000, phases of the Moon and solar and lunar eclipse data through 2050, all planetary occultations through 2020, and much more.

Most observers appreciate a rich meteor shower. A highly illustrated book that describes the parent bodies of these events is *The Cambridge Encyclopedia of Meteorites* by O. Richard Norton (Cambridge University Press, New York, 2002).

For observers of relatively bright deep-sky objects, *Messier's Nebulae & Star Clusters* by Kenneth Glyn Jones (Cambridge University Press, New York, 1991) is a detailed reference. In addition to locator maps and information about the objects, this book contains many interesting historical factoids.

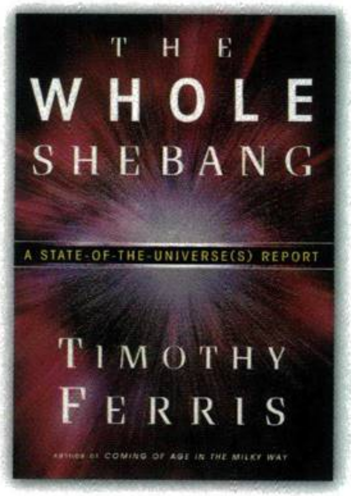
/// THE FIND OF A LIFETIME

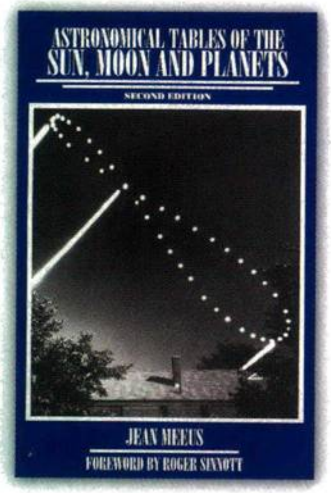
WHEN I'M CONTEMPLATING whether to venture into a used bookstore, I think of three little words that have long served me well: You never know. On a visit to Chicago in the late 1970s, I saw the word "bookstore" out of the corner of my eye. Finding a parking spot blocks away, I excitedly walked back only to discover the shop's full name: The Occult Bookstore. My excitement quickly evaporated. But I was there, so in I went. I meekly asked the clerk if they had any astronomy books, and she pointed upward without taking her eyes off the chart she was studying. I rolled the ladder over, climbed to the top shelf, and almost fell off when I saw a first edition of Mary Somerville's *Mechanism of the Heavens*, written in 1831. This book catapulted Somerville — a Scottish housewife — to superstar status in the early 19th century. Only 750 copies of the first edition were printed, and few of those made it across the ocean to America. I believe it is the most important astronomy book ever written by a woman. With trembling hand, I looked for the price: $13.98 had been crossed out and $9.98 written beside it! Today, the book goes for more than a hundred times that, if you're lucky enough to find it at all. *You never know.*

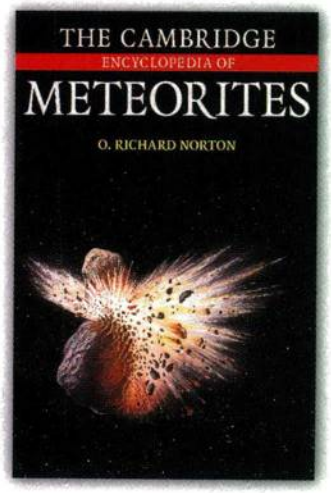
Final thoughts

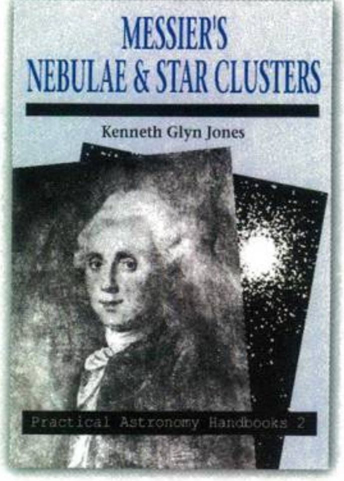
Buy books that interest you, and do this on a regular schedule. Frequent new and used bookstores and take advantage of the Internet. Organize and document your collection. Above all, good luck and remember — enjoy the hunt. ■

Find more astronomy book suggestions at www.astronomy.com/toc


THE WHOLE SHEBANG
A STATE-OF-THE-UNIVERSE(S) REPORT
TIMOTHY FERRIS
AUTHOR OF COMING OF AGE IN THE MILKY WAY


ASTRONOMICAL TABLES OF THE SUN, MOON AND PLANETS
SECOND EDITION
JEAN MEEUS
FOREWORD BY ROGER SINNOTT


THE CAMBRIDGE
ENCYCLOPEDIA OF
METEORITES
O. RICHARD NORTON


MESSIER'S NEBULAE & STAR CLUSTERS
Kenneth Glyn Jones
Practical Astronomy Handbooks 2

ASTROPHOTOGRAPHY

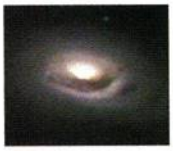
Inexpensive webcams with simple modifications are producing high-quality astronomical portraits. /// BY KEITH WILEY

Imaging with webcams

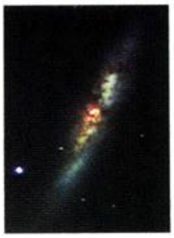
Above, **THE PHILIPS VESTA PRO 675,** shown here in its unmodified state, is a popular webcam for astrophotography. KEITH WILEY

At one time, astrophotography was limited to professionals. Then retail CCD (charge-coupled device) cameras came along, but they continue to cost several thousand dollars each. Just recently, it became possible for amateurs on limited budgets to take long exposures of both planets and deep-sky objects. This breakthrough has been made possible by affordable webcams — devices initially used for 2-way visual communication using personal computers. With cameras that cost less than $200 and readily available software, amateurs can produce striking images matching those taken with much more expensive photographic and imaging equipment.

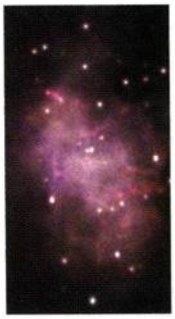
Unfortunately, standard webcams are not ideal for most forms of astrophotography, especially deep-sky photography. The main problem is their limited exposure range. Clever astrophotographers modify webcams to allow longer exposures, but this causes new problems: heat buildup, calibration images that contain unwanted bright spots, and an on-chip amplifier (to boost the brightness) that introduces stray light into the image. Some of these problems can be minimized with hardware, and others can be fixed with software. In combination, these corrective measures enable astrophotographers to take both planetary and deep-sky images that are nothing short of astonishing — without spending lots of money.



THE BLACKEYE GALAXY (M64) in Coma Berenices. Fifty-nine 25-second exposures were stacked.



IRREGULAR GALAXY M82 in Ursa Major. Forty 30-second exposures were stacked.



THE CRAB NEBULA (M1) in Taurus. Exposures of 170 seconds, 163 seconds, and ninety-six 20-second exposures were stacked.

These three images were made with a modified Philips ToUcam Pro on the author's 10-inch Meade LX200 Schmidt-Cassegrain telescope at f/10 with a 0.33 focal reducer and a Sirius Optics MV-1 filter. The capturing and processing software used included K3CCDTools and AiGfxLab. KEITH WILEY

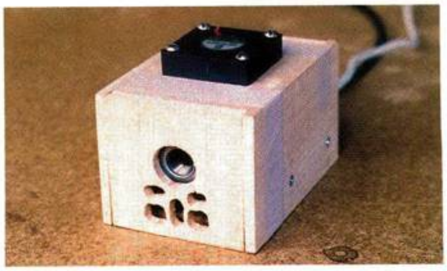
Hardware modifications and software methods used by webcam astrophotographers have been propagated primarily by the on-line community QCUIAG, the QuickCam and Unconventional Imaging Astronomy Group. Newcomers to the group and experienced astrophotographers alike trade tips, experiences, and digital images on a regular basis. If you are considering deep-sky webcam astrophotography, start by looking at the QCUIAG web site (www.qcuiag.co.uk). Group member Steve Chambers, who developed the webcam modification discussed below, offers detailed information on his own site (home.clara.net/smunch/wguide.htm).

Equipment

It's important to select the right webcam. Choose a webcam with a CCD sensor, not a CMOS (complimentary metal-oxide silicon) sensor. CMOS webcams incorporate low-sensitivity sensors and are not suited for astrophotography. For planetary imaging, the QCUIAG community widely believes the Philips ToUcam Pro 740K is one of the best webcams. This camera has a more sensitive CCD sensor than those in most other webcams and also produces excellent color balance. Unfortunately, this camera is out of production and the supply is drying up.

Popular alternatives include the Philips Vesta webcams with CCD sensors such as the 675, the 680, and the 690, and the Logitech QuickCam Pro 4000, which

THIS LOGITECH QUICKCAM PRO 3000 has been modified for long-exposure astrophotography. It cannot be attached to a telescope, however, without a device such as the Mogg telescope adapter. KEITH WILEY



THIS PHILIPS VESTA PRO 675 webcam has been modified to allow long exposures to be taken. When the Mogg telescope adapter is attached (see image to left), the webcam can be mounted to the telescope's focuser. KEITH WILEY

Keith Wiley *is seeking his PhD in computer science at the University of New Mexico. His research focuses on collective robotics.*

/// Various examples of webcam imaging

THE SWAN NEBULA (M17), KEITH WILEY

THE DUMBBELL NEBULA (M27), KEITH WILEY

M64, KEITH WILEY

THE SOMBRERO GALAXY, (M104) KEITH WILEY

THE HORSEHEAD NEBULA, JIM THOMAS

THE DUMBBELL NEBULA, PETER KATRENIAK

THE ESKIMO NEBULA (NGC 2392), KEITH WILEY

NGC 4565, KEITH WILEY

THE RING NEBULA (M57), PETER KATRENIAK

THE WHIRLPOOL GALAXY (M51), ASHLEY ROECKELEIN

recently replaced the functionally identical QuickCam Pro 3000. Vestas also are out of production, but they are easier to find and cheaper than the ToUcam Pro. For long exposures of deep-sky objects, the experience of the QCUIAG community indicates none of these cameras is better than the others. Also, whichever webcam you buy must be modified for long exposures, as explained below. My modified webcam is a QuickCam Pro 3000, which does a great job.

Hooking up

The first concern is how to attach the webcam to the telescope. Various adapters are available, such as "Mogg" adapters (webcaddy.com.au/astro/adapter.htm), which screw into the webcam in place of the removed webcam lens.

When using an unmodified webcam for planetary imaging, use a Barlow lens to increase the size of the planet. If you are doing deep-sky imaging, use a focal reducer to fit large objects (like galaxies) onto the webcam's tiny CCD chip. This has the secondary benefit of increasing the object's surface brightness and decreasing the required exposure time.

Capturing planetary images

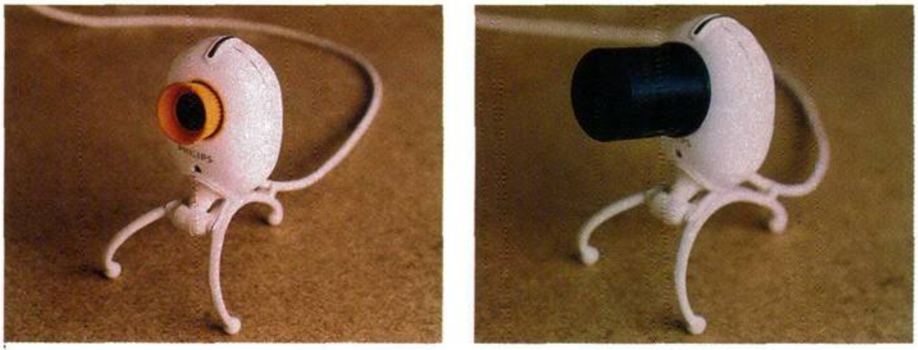
Planetary imaging is relatively simple. Because there's no need to modify the webcam for long exposures, the easiest approach is to use standard webcam software to capture a series of frames. Each frame is one image of the planet. For convenience, capture the images into an AVI or QuickTime movie file. Later, you can batch (or combine) the individual images.

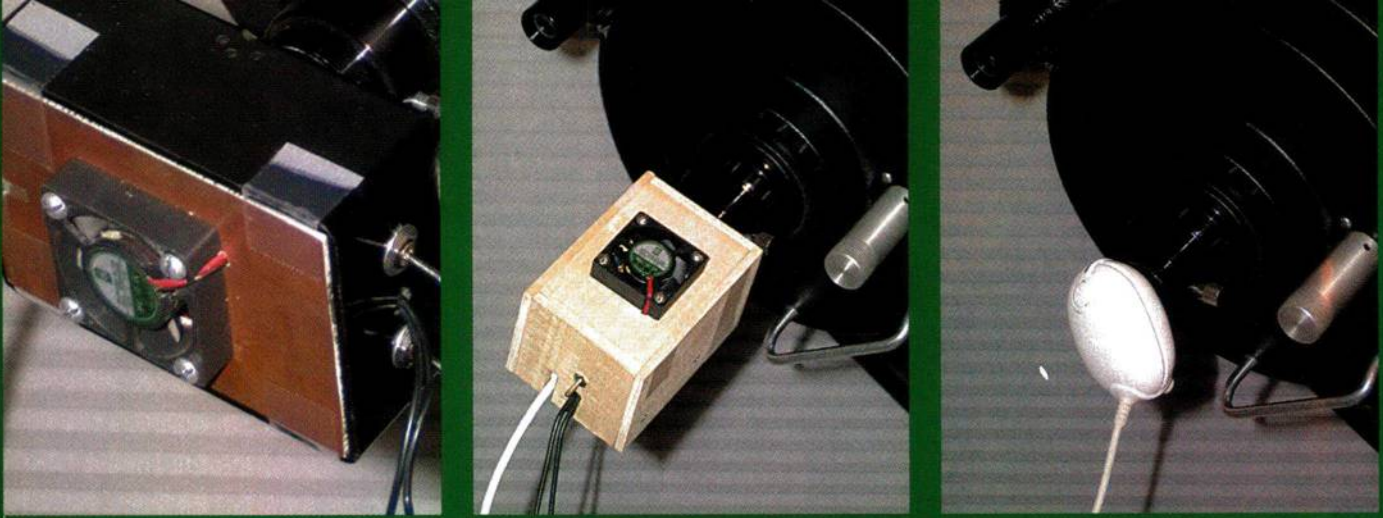
Be aware that a USB connection has a limited bandwidth, meaning it can send data from the webcam to the computer only at a limited rate. Webcams commonly support rates as high as 30 frames per second (fps), this rate is achieved only by performing compression on the images (making them smaller) before sending them over the USB connection. This compression is "lossy." That is, some of the image data is lost. Webcams can support frame rates as slow as 5 fps, and that's the rate I suggest you use. My own tests indicate that transferring files at 10 fps can result in some image degradation, but other people believe 10 fps is acceptable.

Set the gamma control of the webcam (which adjusts the middle tones of the image) to the lowest possible setting. Experimenting will reveal the best settings for shutter speed and gain (relative brightness). High shutter speeds produce images that are not as sharp, so I recommend slow shutter speeds as long as the seeing is good enough to support longer exposures. The goal is to obtain raw frames that are as bright as possible without oversaturating any part of the image.

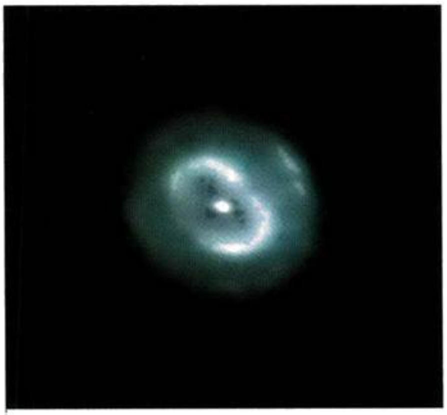
Modifying webcams

Most deep-sky objects are quite dim and require special webcam modifications to permit long exposures. Ordinarily, most webcams cannot take pictures requiring an exposure longer than one-fifth of a second due to built-in shutter speed limitations. A few years ago, however, Dave Allmon and Steve Chambers, two members of the QCUIAG, discovered that some webcams can be modified to take long exposures.

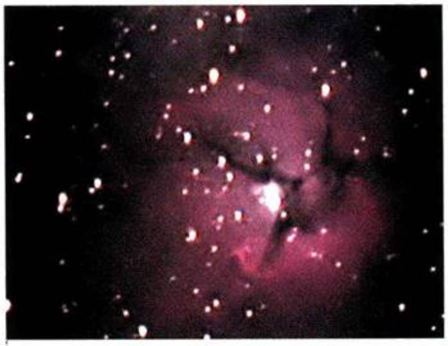

THE PHILIPS ToUCAM PRO 740K has the ability to take quality astroimages even in its unmodified form. Add the Mogg telescope adapter (right) to connect the webcam to a telescope. KEITH WILEY



THE AUTHOR'S 8-INCH CELESTRON Schmidt-Cassegrain telescope makes an excellent instrument for webcam testing and comparison. A modified QuickCam Pro 3000 webcam (left) and a modified Philips Vesta webcam (center) both have small fans attached to aid cooling. A ToUcam Pro webcam (right) is shown in its unmodified form mounted to the telescope. Because it is unmodified, the webcam's maximum exposure is limited to ⅕ second or less. KEITH WILEY



THE BLUE SNOWBALL (NGC 7662) in Andromeda was imaged by Alan Leggett with a modified Philips Vesta 680, Peltier cooled, on a 10-inch Meade Schmidt-Cassegrain telescope. Forty 20-second exposures were stacked to produce this image. The capturing and processing of this image were accomplished using K3CCDTools software.



THE TRIFID NEBULA (M20) in Sagittarius was imaged by Peter Katreniak of Kosice, Slovakia, with an *8-inch Orion Europa* Newtonian reflector at f/6 and a modified Philips Vesta Pro 675 webcam. Eleven 25-second exposures were stacked. The capturing and processing software used were K3CCDTools, MaximDL, Corel PhotoPaint, and Neat Image.

The simplest modification required to obtain long exposures consists of disabling the camera's one-fifth second exposure upper time limit and splicing in a switch. This switch can specify the start and end for an exposure of arbitrary length. For Windows users, the switch can be controlled through a parallel port by software.

For Macintoshes, which do not have parallel ports, other workable solutions exist. I developed original software that allows me to manually control individual exposures with a switch. I can tell the camera when to start and stop an exposure, after which the software sends it to the Macintosh over its standard USB connection. Once the image reaches the Macintosh, a program I wrote automatically detects its arrival and saves it. Computer control of the exposure time not only helps ensure that multiple exposures are precisely the same duration (important for later combination of images), but it also allows the computer to capture an entire batch of long exposures without any human intervention.

Additional modifications

A number of optional modifications exist as well. For example, the amplifier on the webcam, which produces a soft glow that accumulates during long exposures, can be disabled. Some people have replaced a webcam's original CCD chip with a more sensitive and larger chip.

CCD chips, whether in standard CCD cameras or webcams, heat up. Use a device called a Peltier cooler, or at least a simple fan, to cool the CCD and reduce "noise" generated by heat. The QCUIAG web site has general information on modifying webcams for long exposures, including links to numerous personal web sites that have detailed instructions on how to perform this modification.

Exposure limits

How long an exposure can you make with a modified webcam? Unlike users of standard CCD cameras, which can expose a single image for more than an hour, members of QCUIAG usually shoot "long" exposures in the range of 10 to 120 seconds, the upper limit imposed by simpler modifications. More advanced modifications allow somewhat longer exposures but suffer from the webcam's 8-bit CCD chip, which saturates with skyglow fairly quickly.

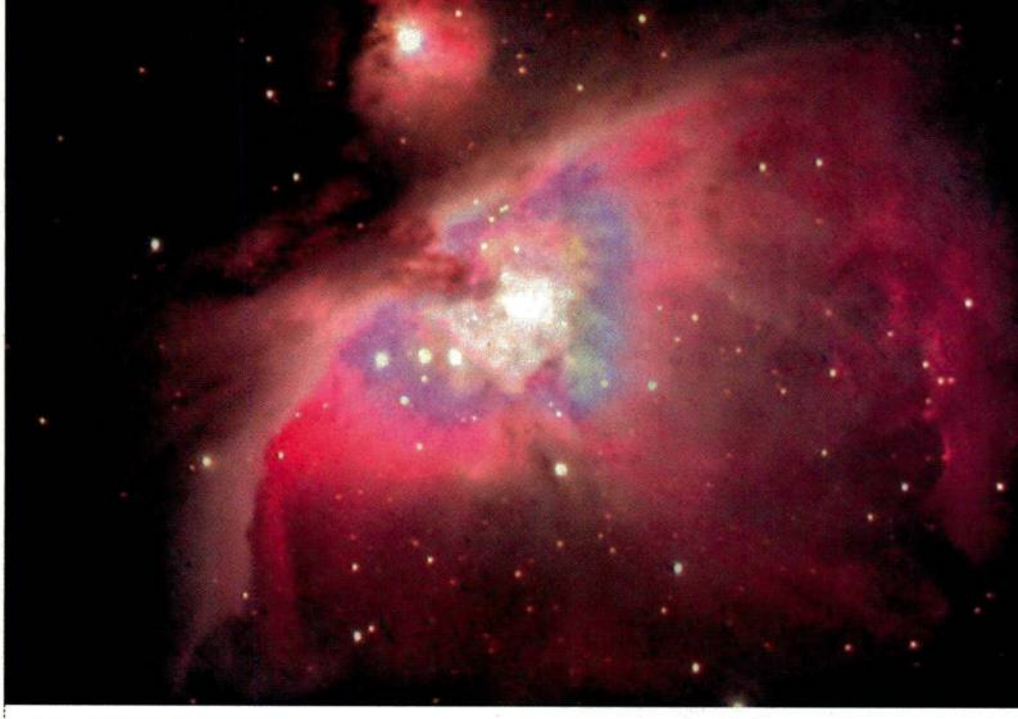
Webcam imagers have learned the power of image stacking (combining multiple images to create a single, final image) and thus prefer twenty 30-second exposures to a single 10-minute exposure. Image stacking produces a much better image than a single, extremely long exposure.

Image postprocessing

For a single deep-sky object, members of QCUIAG often capture ten to one hundred images. When imaging planets, they can capture several hundred frames in no more than a minute or two. Postprocessing — using software to improve the images after you have created them — produces a single, final image.

When shooting a long exposure, the CCD accumulates dark noise. Dark noise consists of the information a CCD chip gathers during an exposure taken in complete darkness (such as with a cover over the webcam). Such an image is called a dark frame. Because of its name and the way it's made, you would expect a dark frame to be perfectly black, but it is not. Because dark frames don't represent actual light hitting the CCD chip but rather electronic noise that is part of the system, the best solution is to "subtract" the dark frame from individual images before any other processing takes place. Use dark frames that correspond to the exposure time of your images and the temperature at which they were taken (dark frame noise varies with temperature). You also should capture a few dark frames for each set of images you take because temperatures can vary nightly — and even hourly.

It can help to divide the image by a flat field — an image of an object with even brightness. This procedure compensates for uneven sensitivities across the CCD's imaging area. For example, some focal reducers (used to decrease the focal ratio of telescopes to produce a "faster" system) introduce soft vignetting into the image, which makes the image darker around its edge. To capture a flat field, shoot the twilight sky (it has a very even illumination).



THE ORION NEBULA (M42) was imaged with a modified Logitech QuickCam Pro 3000 mounted on a Meade 8-inch LX200 Schmidt-Cassegrain telescope at f/6.3 with a 0.6 focal reducer. Exposures of 1, 2, 5, and 20 seconds were stacked. The capturing and processing software used included Keith's AstroImager, Keith's Image Stacker, and Photoshop. KEITH WILEY

The best way to increase the quality of the final image is to stack many images of the same object. Before stacking, however, it is important to register (or align) the images. Alignment consists of adjusting the horizontal and vertical positions of each image so they all line up perfectly.

/// IMAGE PROCESSING

Processing images is just as important as obtaining them. The most important image-processing operations employed by astrophotographers are dark-frame subtraction, flat-field division, image registration (or alignment), stacking (or averaging), sharpening, and histogram remapping (or level adjustment). The programs listed below perform these operations and are available at no cost.

For Macintosh:

- Keith's Image Stacker by Keith Wiley, www.unm.edu/~keithw/keithsImageStacker.html

For Windows:

- Registax by Cor Berrevoets, aberrator.astronomy.net/registax
- K3CCDTools by Peter Katreniak, www.pk3.org/Astro (click on "My Software")
- AstroVideo by the COAA, www.ip.pt/coaa/astrovideo.htm
- Astrostack by Robert Stekelenburg, www.astrostack.com

Stacking every image you've captured is generally counterproductive. In a set of planetary images, for example, some will be subject to bad seeing. A fraction of the images of a deep-sky object may show drift errors associated with bad polar alignment. Even a slight breeze can blow your telescope just enough to smear a long exposure. Such bad individual images obviously would degrade the stack. Image postprocessing software lets you manually discard individual frames. It even automatically selects good frames without too much intervention on your part. The software does this by favoring images with strong energy in the higher frequencies — in other words, sharper frames.

Stacking serves two purposes. It increases the signal-to-noise ratio (s/n) by a factor equal to the square root of the number of images stacked. For example, stacking nine images increases the s/n by three; stacking twenty-five images gives a fivefold s/n increase. Stacking also increases the dynamic range (the difference between the maximum and minimum brightnesses of an image). The s/n increase that accompanies stacking produces an image better than any of the original images. This is useful primarily for planetary images, in which the object has a low dynamic range and single frames are unclear.

The effect of s/n improvement can seem downright magical the first time you witness it. The increased dynamic range allows objects with both bright and dark regions to preserve a wide range of luminosity. S/n improvement also is essential for deep-sky objects such as galaxies, in which the cores are often much brighter than the outlying regions.

Once some form of stacking has reduced your set of images to a single image, still more can be done to improve its quality. Stacked images are often blurry. Sharpening techniques contained in image-processing software can reveal greater detail. Histogram remapping (or level adjustment) is a common tool used to reduce the range of that part of the image's histogram that doesn't contain much information and stretch ranges that are interesting. This makes the details within those ranges more visible.

Recent webcam developments provide many opportunities for amateur astronomers to obtain fantastic photographs of planets and deep-sky objects. Taking advantage of these opportunities requires only two simple components: hardware modifications of inexpensive webcams and software for image processing that is now available on the Internet. ■

To learn more about CCD imaging, visit www.astronomy.com/toc

LUMICON

LUMICON FILTERS "World's Best"

SWAN BAND
CON SWAN BAND
LUMICON

Lumicon International offers you the best and most extensive line of astronomical filters in the world. Filters for every imagined visual and astrophotographic application, in many configurations and sizes. Filters for deep-sky objects, galaxies, nebulae, planets, planetary nebulae, light-polluted skies, comets, and solar prominences. All UHC, Deep Sky, Oxygen III, and H-Beta filters are individually inspected and tested on a Perkin-Elmer Double-Beam Spectrophotometer. We proudly inscribe the % transmission for each of the primary lines. All made in the USA, and assembled in our new factory in California. All Lumicon International products come with a 100% satisfaction guarantee. Please visit our website at: www.lumicon.com for further information.

LUMICON DEEP SKY FILTER

The Lumicon Deep-Sky Filter is THE foremost broadband filter, blocking ALL mercury-vapor as well as high & low pressure sodium-vapor lamp light, neon lights and airglow, while transmitting the rest of the visible spectrum. The superior contrast gain between the object you're viewing and the black background of space allows you to enjoy viewing galaxies, nebulae, star clusters, comets, etc. from light-polluted urban skies, making it the best all-around visual light pollution filter. Ideal for visual or photographic use.

.965" – $89.95 • 1.25" – $99.95 • Brandon 1.25" – $99.95 • 2" T-Threaded – $199.95 • 48mm – $199.95 • 72mm – $399.95 • Visual Back – $199.95 • 39mm Nikon – $299.95 • 43mm Nikon – $299.95

LUMICON UHC FILTER

The original Lumicon Ultra-High-Contrast narrow bandpass filter (24nm) isolates the two doubly-ionized oxygen lines (496 and 501nm lines) and the H-beta line (486nm) emitted by planetary and most emission nebulae. The result is superb views of the Orion, Lagoon, Swan and other extended nebulae. This makes the Lumicon UHC the best all-around dark-sky nebular filter available.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON OXYGEN III FILTER

The renowned, original Lumicon OIII narrow bandpass filter (11nm) isolates just the two doubly-ionized oxygen lines (496 and 501nm lines) emitted by planetary and extremely faint nebulae. Produces near-photographic views of the Veil, Ring, Dumbbell and Orion nebula, among many other objects. You will be amazed at what the OIII filter allows you to see!

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

LUMICON HYDROGEN-BETA FILTER

The Lumicon H-Beta Filter isolates only the Hydrogen-Beta line of the spectrum (486nm). Now you can view extremely faint, special objects such as the Horsehead, Cocoon and California Nebulae. In many cases, the Lumicon H-Beta Filter is the ONLY way to view these objects. A steady, transparent sky, with an 8" or larger instrument, combined with the Lumicon H-Beta Filter, all make an unbeatable combination for viewing those "notch in the belt" objects.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

LUMICON NIGHT-SKY H-ALPHA FILTER, FOR BLACK AND WHITE DEEP-SKY PHOTOGRAPHY

The Lumicon Night-Sky H-Alpha Filter is a powerful photographic aid in overcoming light pollution during deep-sky photography, and will help you achieve strikingly improved results in telephoto lens B&W astrophotography. It is ideally matched to hypersensitized 2415 film, and will reduce light pollution 10-fold, making it ideal for photography of faint emission nebulae.

Transmission for this sharp-cut-off filter is zero below 630nm, 90% at Hydrogen-Alpha 656nm, and 90-98% from 656nm to the near infrared. Both filter surfaces have high-efficiency anti-reflection coatings for maximum performance.

Exposures may be increased 2-10 times with the Night-Sky H-Alpha Filter, depending on the faintness of the nebula.

48mm–$69.95 • 58mm–$79.95 • 77mm–$89.95 • 82mm–$99.95

48MM COLOR FILTERS

Used in lunar and planetary observing.

Red – $29.95 • Orange – $29.95 • Yellow – $29.95 • Green – $29.95 • Blue – $29.95 • Ultra-Violet (Clear) – $29.95 • Polarizer – $49.95 • Neutral Density – $39.95

1.25" lunar & planetary photo-visuals, world's best, coming soon.

LUMICON MINUS VIOLET FILTER FOR COLOR OR BLACK AND WHITE PHOTOGRAPHY

The Lumicon Minus Violet Filter greatly improves photographs taken through lens systems, producing pinpoint star images. It is especially recommended for all telephoto lenses. This filter is made from optically flat, specially-made colored glass, and has anti-reflection coatings on both surfaces.

Recommended Films

All films can be used with the Minus Violet Filter; hypersensitized 2415 is the recommended B&W film, and is available directly from Lumicon or from any of Lumicon's authorized dealers.

Visual Use

The Minus Violet Filter can eliminate or greatly reduce the blue halo sometimes seen around stars through refracting telescopes. It is ideal for observing the moon and planets.

48mm – $49.95 • 58mm – $59.95 • 72mm – $69.95

LUMICON INFRARED BLOCKING FILTER

The Lumicon Infrared Blocking Filter completely blocks all infrared light above 750nm. Its versatile, anodized aluminum cell has 42mm male T-threads on one side and 48mm male threads with 42mm female T-threads, internal, on the other. Great for CCD camera infrared blocking purposes.

2" – $99.95

Infrared Blocking Filter 1.25" coming soon.

LUMICON UV DUST SEAL FOR MOST SCTs

The Lumicon UV Dust Seal keeps dust and insects out of your telescope. The seal mounts on the back of your SCT and accepts all attachments. It is an ultraviolet filter that passes all visible wavelengths of light with minimal absorption, no aberration, and no noticeable internal reflections. Fully Multi-Coated.

5-9.25" SCT / Mak – $39.95 • Meade 10/12/14" – $89.95 • Celestron 11/14" – $89.95

LUMICON COMET BAND FILTER

Lumicon's narrow visible bandpass (25nm) Comet Band Filter isolates the 501nm OIII and the Cyanogen lines at 511nm and 514nm. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Band Filter also helps you to better distinguish gaseous comets from dusty comets which show little contrast gain. For dusty comets, use the **Lumicon Deep Sky Filter**.

Howard Brewington, famed comet discoverer says: "I discovered Comet Aarseth-Brewington, 1989a1, using the Lumicon Comet Band Filter. The filter doubled the contrast, making the comet very easy to spot." Be the person to discover the next "Comet of the Century" using the Lumicon Comet Band Filter.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

SOLAR PROMINENCE FILTERS

The 1.5 Ang. Lumicon Solar Prominence Filter system lets you see the awe-inspiring solar prominences jutting from the edge of the sun. Sunspots and bright filaments can also be seen on the sun's surface. The filter has a 2" barrel for insertion into 2" focusers, and can be easily adapted for 1.25". It also has camera T-threads and a viewing adapter for 1.25" eyepieces.

Solar Prominence Filter $699.95 • 58mm Energy Rejection Prefilter – $169.95 • 77mm Energy Rejection Prefilter – $199.95

Off-Axis Mask for 8" SCT – $69.95 • Off-Axis Mask for Meade 10" – $89.95 • Off-Axis Mask for C11 – $99.95 • Off-Axis Mask for 12" LX200 – $99.95 • Off-Axis Mask for C14 – $119.95 • Off-Axis Mask for M14 – $119.95 • Off-Axis Mask for 16" LX200 – $129.95

MULTIPLE FILTER SELECTOR

The Lumicon 1.25" Multiple Filter Selector lets you switch instantly back and forth between your Lumicon 1.25" filters without having to constantly thread and unthread them from your eyepieces. You may leave one of the 5 slots open to compare filtered and unfiltered views. – $129.95

EASY GUIDERS

All of Lumicon's famous off-axis guiders feature Lumicon's patented radial and rotational off-axis adjustments – combined with a large off-axis pick-off prism, making bright guide star selection a breeze.

CASSEGRAIN EASY GUIDER FOR 7" TO 9.25" SCTs

The Lumicon Cassegrain Easy Guider allows off-axis guiding with your Cassegrain telescope while reducing the f-ratio from f/10 to f/6.3 using a large, fully-coated focal reducing lens. The faster f-ratio, combined with the ease of finding and guiding on bright guide stars, minimizes guiding error, making for successful astrophotos. Threaded for 48mm filters. Specify camera type when ordering.

Celestron 5 – $249.95 • 7" Mak – $249.95 • 8" SCTs – $249.95 • Celestron 9.25" – $249.95

GIANT EASY GUIDER FOR 10" TO 16" SCTs

The Lumicon Giant Easy-Guider is a powerful photo/visual tool, utilizing an 80mm multicoated compression lens to reduce your Schmidt-Cassegrain's f/10 optics to f/6.3 for wide-angle photography. Ideal for 35mm and 120 format film with 100% edge-to-edge illumination and pinpoint star images. All other off-axis guiders have prisms and focal reducing lenses a fraction the size of the Lumicon Giant Easy Guider's. Threaded for all Lumicon 48mm filters. Specify camera type when ordering.

10", 12", 14" and 16" Meade – $399.95 (Meade 16" LX200 requires adapter - $169.95) • 11" and 14" Celestron – $399.95

NEWTONIAN AND REFRACTOR EASY GUIDER

The Lumicon Newtonian and Refractor Easy Guiders allow off-axis guiding directly through the main telescope, thus preventing differential flexure between telescope and guide scope that can ruin your astrophotos. Low-profile design installs in seconds into 1.25" and 2" focusers. Threaded for 1.25" and 48mm filters. Specify camera type when ordering.

1.25" and 2" Newtonian – $189.95 • 1.25" and 2" Refractor – $189.95

LUMICON EASY GUIDER ACCESSORIES

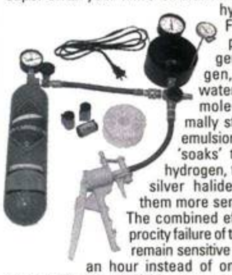
- Newtonian Easy-Guider Focal Reducer Lens in Cell – $79.95
- Giant Easy-Guider Focal Reducer Lens in Cell – $199.95
- Giant Easy-Guider - No Lens – $319.95
- Cassegrain Easy-Guider - No Lens – $219.95

LUMICON 3X RELAY DIAGONAL FOR USE WITH EASY GUIDERS

Lumicon Relay Diagonal's 3x Barlow lens increases the guiding magnification in the off-axis portion of your Lumicon Easy-Guider, increasing off-axis guiding ease and precision. – $99.95

HYPER KITS

LUMICON FILM HYPERSENSITIZATION KITS



Film hypersensitization with a Lumicon Hyper-Kit super-dries your film's emulsion using nitrogen and hydrogen (Lumicon's Forming Gas: 8% prepurified hydrogen, 92% prep. nitrogen, removing ALL water vapor and oxygen molecules, thus thermally stabilizing the film's emulsion. The process also 'soaks' the emulsion with hydrogen, thus sensitizing the silver halide crystals, making them more sensitive to faint light. The combined effect reduces reciprocity failure of the film, allowing it to remain sensitive to light well beyond an hour instead of only a few minutes. Hypered film is a MUST for anyone who is serious about taking deep-sky photographs.

LUMICON MODEL 300 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

For simplest hypering with film still in its metal cassette, the Model 300 Hyper-Kit is easy in use and safe for your film. Operates with Lumicon's Forming gas at 30° C. Hypers film in two to five days.

Chamber Only – $249.95 • Film Hyper Kit – $375.95 • Hyper Kit O-Ring Set – $9.95

LUMICON MODEL 600 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

The versatile Lumicon Model 600 Hyper-Kit is capable of hypering film either while still in its metal cassette at 30° C, or more quickly with highest saturation on the open reel at 50° C. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas.

Chamber Only – $299.95 • Film Hyper Kit – $475.95 • Hyper Kit O-Ring Set – $9.95 • Hyper Kit Hand Vacuum Pump – $39.95 • Hyper Kit Vacuum Pump Handle – $9.95

LUMICON MODEL 1200 FILM HYPERSENSITIZATION KIT FOR 35MM, 120, AND 4x5 FILM

Large-capacity Lumicon Model 1200 Hyper-Kit accepts 4x5 film. Kit is capable of hypering film in just 12-to-20 hours with highest saturation. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas at either 30° or 50° Centigrade for simple or advanced modes of operation.

Chamber Only – $379.95 • Film Hyper Kit – $751.95 • 4x5 Plate Holders – $99.95 • Hyper Kit O-Ring Set – $9.95

HYPER KIT ACCESSORIES

- 4x5 Sheet Film holder – $99.95
- 35L Cylinder of Forming Gas – $145.95
- 30° C Temperature Sensor Probe – $99.95
- 50° C Temperature Sensor Probe – $99.95
- Temperature Controller – $139.95 • Electric Vacuum Pump – $349.95 • 220 V option on Vacuum Pump – $44.95 • 220V/110V Converter – $29.95 • Vac/Pressure Hose with Clamp – $9.95

ASTROPHOTOGRAPHY FILM

HYPERED FILMS

Use Lumicon Hypersensitized Film to take stunning astro photographs. Allows you to expose film on your favorite deep sky object far longer, with no fog buildup, than does non-hypersensitized film.

Fuji G800 – $19.95 • Fuji RD100 – $14.95 • TP2415 B&W – $19.95 • TP6415, 120 – $19.95 • Kodak P1600 – $24.95 • Kodak PPF400 – $19.95 • Kodak PPF400, 120 – $19.95

NON-HYPERED FILM

Lumicon's high-contrast, extremely fine-grained film. High quality for medium-format astrophotography.

TP2415, Bulk 150' Roll – $79.95 • TP2415, Normal 36 exposure – $11.95 • TP4415, 4x5" Normal 25 Sheets – $49.95 • SO-279 Vericolor Slide Film – $14.95 • Kodak 6415, Normal Film – $9.95 • Fuji G800, Normal Film – $9.95 • PPF400, 120, Normal Film – $11.95 • PPF400, 120, Normal Film - 5 pack – $49.95 • Kodak P1600, Normal Film – $19.95 • Fuji Sensia RD100, Normal Film – $9.95

FILM DEVELOPING MATERIALS

- Film Changing Bag – $ 16.95
- Kodak D19 B&W Developer – $ 19.95
- Patterson film developing tank – $19.95

DIAGONALS

ENHANCED ALUMINUM STAR DIAGONALS

The Lumicon Enhanced Aluminum Star Diagonal reflects 96 to 97 percent of the light from the telescope's primary optics into your eyepiece. Its single 1/10 wave precision-polished surface is superior to the three surfaces of prism diagonals, and its enhanced coating is more durable than a standard aluminum coating. Lumicon collimates each star diagonal using a double-pass collimator, ensuring that the light reflected from the diagonal is perfectly perpendicular to the telescope's optical axis. 1.25" – $99.95 • 2" – $189.95 includes 1.25" adapter.

LUMIBRITE STAR DIAGONAL

The Lumicon Lumi-Brite Dielectric-Coated Diagonal reflects >98 percent of the light from the telescope's primary optics into your eyepiece. Not only is the Dielectric Coating more durable than a standard aluminum coating, it is also smoother, resulting in higher image contrast. 1.25" – $149.95 • 2" – $239.95 includes 1.25" adapter

SKY VECTOR

The Lumicon Sky Vector is a state-of-the-art digital setting circle system, providing virtually any astronomical telescope, whether equatorial or altazimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. With the Sky Vector, you will be able to find objects even faster than with most fully computer-driven telescopes. Its alphanumeric display uses a simple, easy-to-read scrolling text format. There is no need to polar align or to enter Latitude, Longitude, Date, Altitude, and Sidereal time – just initialize on one or two stars and you're ready to go!

SKY VECTOR 1

The Lumicon Sky Vector 1 features: One- or two-star initialization; 4000-step encoders for high-resolution accuracy (0.09 deg.); Digital Right Ascension coordinate readout to 1 minute; Digital Declination readout to 10 arc-minutes; Guide mode for guiding you to the selected object in current memory; Database containing over 220 of the finest objects in the sky, including the popular "Messier Catalog."

Complete Set – $349.95 • Kit only – $269.95

LUMICON NGC SKY VECTOR

The Lumicon NGC Sky Vector has all the features of the Sky Vector 1, plus a large 12,000-object database, higher resolution display modes, IDENTIFY mode, and current constellation and chart number displays - all on a 16-digit red LED display. It can be integrated with a personal computer for display of celestial object coordinates.

Complete Set – $489.95 • Kit only – $419.95 • Serial Cable – $29.95

SKY VECTOR UPGRADES

- Upgrade 3.65 Chip Set for NGC Sky Vector. – $59.95
- 8192-Step Encoder Set. Can be purchased separately or in place of the standard 4000 step encoders. – $29.95

LUMICON SKY VECTOR HARDWARE PACKAGES

Lumicon Sky Vector Hardware Package for Meade and Celestron SCTs includes: declination encoder bracket, right ascension encoder holder, encoder shaft holders, Allen wrench, and instructions.

Lumicon Sky Vector Hardware Package for Dobsonian telescopes includes: brass azimuth bolt, stainless steel azimuth encoder bracket, aluminum altitude-encoder-shaft holder, stainless steel altitude encoder bracket, 10 wood screws, Allen wrench, and instructions.

C5+ – $79.95 • C8 – $69.95 • Celestar 8 – $79.95 • Celestar 8 Dlx – $79.95 • G8/G11 – $349.95 • Ultima 8 – $79.95 • Ultima 11 – $99.95 • C11 – $79.95 • C14 – $129.95 • Meade 2080 – $69.95 • 2120 – $79.95 • 8" Dob – $69.95 • 10" Dob – $69.95 • 12/13" Dob – $79.95 • 16/17" Dob – $89.95 • CI700 – $299.95

RICHFIELD VIEWERS

RICHFIELD VIEWER FOR 7" TO 9.25" SCTs

The Lumicon Richfield Viewer takes your Schmidt-Cassegrain's f/10 optics and reduces them to f/6.3 for beautiful wide-field views. Its fully-coated 50mm diameter focal reducing lens has a larger clear aperture and less coma than higher-priced focal reducers on the market, providing superb unvignetted views. Barrel accepts 2" star diagonals. Comes with an aluminum 2"- 1.25" eyepiece reducer, threaded for 48mm filters. – $99.95

RICHFIELD VIEWER, THREADED FOR 7" TO 9.25" SCTs

Threads directly into telescope. – $99.95

RICHFIELD VIEWER, SLIDE-ON, FOR 7" TO 9.25" SCTs

For attachment onto SCTs that have the Lumicon Easy-Guider threaded attachment ring in place. Slides over attachment ring. – $99.95

GIANT RICH-FIELD VIEWERS

LUMICON GIANT RICH-FIELD VIEWER FOR LARGE SCTs

Takes your large Schmidt-Cassegrain f/10 optics and reduces them to f/6.5 for the widest possible views of large galaxies like M31, M33 and NGC 253, and pairs of galaxies like M81 and M82. Moving the 80mm diameter focal reducing lens to the forward position in the Rich-Field Viewer body yields an even wider field. Comes with a 2"- 1.25" eyepiece reducer, threaded for 48mm filters.

10" SCTs – $279.95 • Celestron 11" – $279.95 • 12" SCTs – $279.95

LUMICON 2.5X CCD COMPRESSOR

This cost-effective, fully-coated lens widens the telescope field and yields pinpoint star images for small to medium-size CCD cameras. Has male threads for standard 1.25" eyepieces or camera-type barrels. – $129.95

LUMICON 48MM COMA CORRECTOR FOR NEWTONIAN EASY GUIDER OR 2" EYEPIECE

The Lumicon Coma Corrector lens dramatically reduces coma when used, in particular, with f/3.5 to f/6 Newtonian telescopes. It makes off-axis star images much smaller, thus improving photographic quality and making guiding much easier. Free of all chromatic aberration and fully multicoated to prevent ghost images. Can be used on all 48mm threaded accessories. Neither shrinks nor magnifies the image. – $239.95

LUMICON 1.5x–1.8x MULTIPLIER/FIELD FLATTENER

The Lumicon Multiplier / Field Flattener Lens has been custom computer-designed to increase image scale with the flattest field possible for photography and visual use with fast Newtonian Telescopes. This lens is suitable for use with f/3.5 to f/6 systems. Fully multicoated for maximum light transmission. – $259.95

FINDERSCOPE

Lumicon 80mm SuperFinder for Right-Angle viewing. This finder telescope actually lets you see many of the deep-sky objects you are looking for, complementing any telescope having 8 or more inches of aperture. It also makes for a wonderful rich-field telescope for beautiful views of the Milky Way. Comes with 25mm, 1.25" cross-hair eyepiece and helical drawtube-type focuser.

50mm RA Finder - Body Only – $79.95 • 50mm RA Finder - Complete – $149.95 • 50mm Straight-Thru Finder - Body Only – $79.95 • 50mm Straight-Thru Finder - complete – $119.95 • 80mm Right Angle SuperFinder - Body Only – $199.95 • 80mm Right Angle SuperFinder with Tripod Block – $219.95 • 80mm Right Angle SuperFinder - Complete – $299.95 • 80mm Straight-Thru SuperFinder - Body Only – $199.95

FINDERSCOPE BRACKETS

This two-ring finder bracket firmly holds finderscopes to your telescope while allowing precise alignment with the main optical axis. The base is radius-cut to fit snugly against the telescope's main tube, and the dovetail groove makes it easy to install or remove the finderscope from the base. Fastens in brand name SCT telescope mounting holes.

- 50mm Finder Bracket, 8", 10/11", and 14" – $49.95
- 80mm Finder Bracket, 8", 10/11", and 14" – $59.95

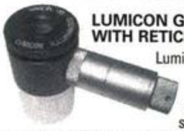
- Universal Dovetail Bracket for 50mm finder – $39.95
- 2 traditional universal ring-type brackets for 50mm finder – $19.95

LUMICON 25MM CROSS-HAIR FINDERSCOPE EYEPIECE

This well-made 25mm, 1.25" Kellner single-crosshair finderscope eyepiece is ideally suited for Lumicon's 50mm and 80mm SuperFinders. High contrast and flat field. Non-illuminated. – $69.95

GUIDING EYEPIECE

LUMICON GUIDING EYEPIECE WITH RETICLE ILLUMINATOR



Lumicon's top-quality 12.5mm, 1.25" Orthoscopic eyepiece with focusable dual cross hair for precision guiding. Incorporates new state-of-the-art cordless Reticle Illuminator, featuring rheostatic brightness control and on/off switch.

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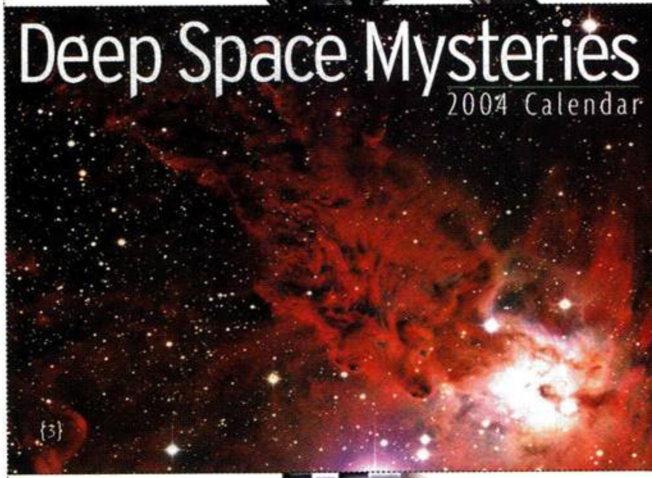

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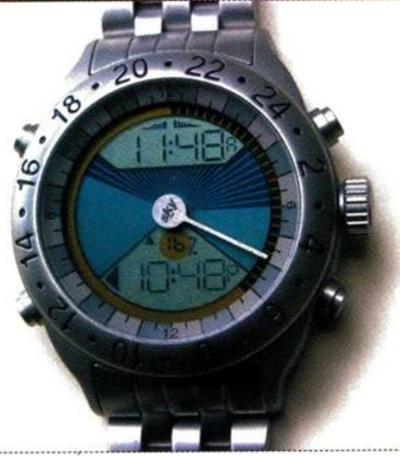

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Co-Authored By: **MIKHAIL N. DOODNIK, GUY I. SEVERIN, ANATOLY YU. STOKLITSKY,** and **VITALY I. SVERTSHEK**

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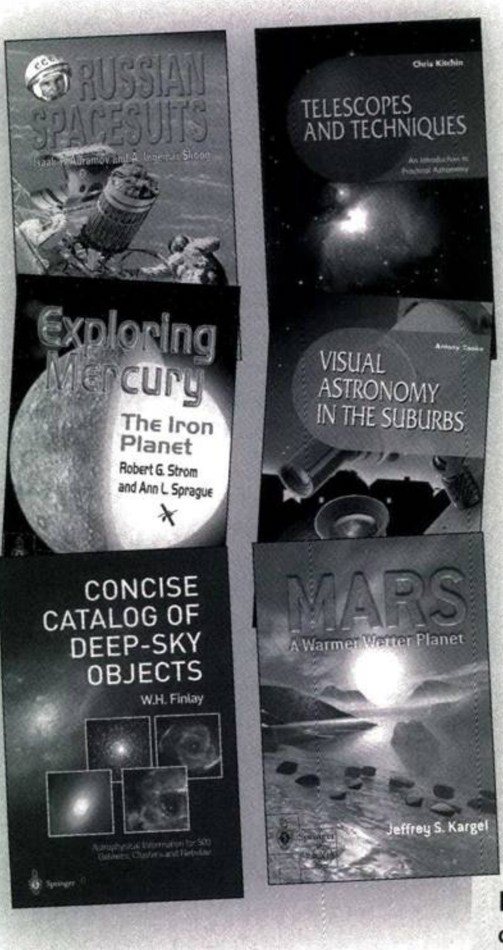
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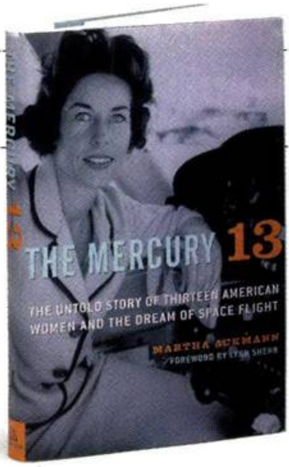
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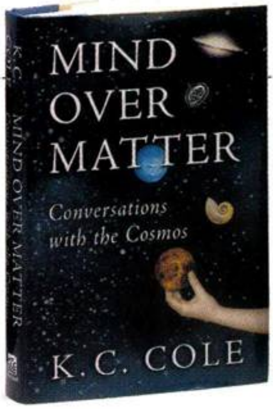
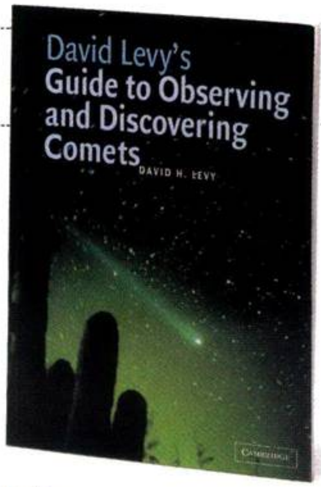




The Mercury 13: The Untold Story of Thirteen American Women and the Dream of Space Flight

Martha Ackmann, 256 pages, Random House, New York, 2003; ISBN 0–3755–0744–2; hardcover, $24.95.

When *The Mercury 13* arrived, I picked it up with anticipation and a bit of trepidation. An astronaut myself, I was curious about what it was like when the United States refused to send women into space. Still, I was afraid reading the history book would feel like homework.

I shouldn't have worried. Author Martha Ackmann unearthed documents, culled news reports, and interviewed central players to profile thirteen remarkable women who excelled not only in aviation but also in courage. Tagged "the Mercury 13," this group of women passed the same hurdles as the "Right Stuff" crowd, at times in high heels or corsets. They set world records in altitude and non-stop distance flying and clocked thousands of hours of flight time in a variety of aircraft, sometimes under dangerous conditions. Tested for tolerance to the isolation and weightlessness of space, the women shattered the standards of their male counterparts, who were being groomed to become the first astronauts.

In 1962, these women asked "as citizens of this nation to be allowed to participate with seriousness and sincerity in the making of history now." And even though qualification exceptions were made for John Glenn and Scott Carpenter, these women were rejected in their quest to become astronauts. At a hearing on government discrimination against women in space, they challenged statements such as this by Glenn: "The fact that women are not in this field is a fact of our social order."

The Mercury 13 is a feast of historical tidbits from 1955 to 1964, when the U.S. space program was being shaped. Ackmann details the self-interest, political shenanigans, fear, bias, misguided loyalty, ego, privilege, and societal barriers that kept U.S. women out of space until 1983, twenty years after the Russians launched Valentina Tereshkova into orbit.

Readers come to know Jerrie Cobb, Janey Hart, and Jacqueline Cochran, crackerjack female pilots breaking records alongside Chuck Yeager. We discover that Lyndon Johnson scribbled "Lets Stop This Now" [*sic*] across a memo supporting the selection of women astronauts. We learn about hearings; supportive and jealous husbands; space heroes guarding their turf; disappointment; bitterness; and triumph. It's all in there — and it's all true!

Much of the book resonated with me. As a child in the '60s, I considered the notion that women were not capable idiotic — the smartest kids in my class were girls, and I knew strong, physically adept women. It was difficult to explain to my friends and family why they, African Americans, should be excited about the U.S. Moon landing. Although their tax money was up there, there was no evidence they would be!

In writing this review, I could barely refrain from writing an essay on NASA, sexism, racism, and the space race. I got so caught up in the story, I didn't notice the way it was written. But I guess that's what makes a book good — it artfully puts the reader smack-dab in the middle of history without any trace of self-awareness. And *The Mercury 13* is very, very good.

— **MAE JEMISON** *is a physician and businesswoman who became the first woman of color in space in 1992.*

Mind Over Matter: Conversations with the Cosmos

K. C. Cole, 336 pages, Harcourt, San Diego, 2003; ISBN 0–1510–0816–7; hardcover, $25.

We live in a gravitational pothole in spacetime "created by the sagging weight of the Earth in the four-dimensional fabric that serves . . . as the backdrop for our universe." Thus likening the force of gravity to the concrete effect of a bowling ball on a bedspread, K. C. Cole begins *Mind Over Matter: Conversations with the Cosmos*, a collection of her columns from the *Los Angeles Times*. With pithy titles such as "Clouds" and "Murmurs," the imaginative essays cleverly navigate the complex mysteries of astronomy and physics.

Her breezy, stream-of-consciousness musings demonstrate the amazing array of scientific tidbits she has at her fingertips. Unfortunately, the tossed-salad writing style of some essays feels like a bit of a tease. The tantalizing mention of a recent magnetar blast that "rocked Earth's ionosphere" is quickly dropped in one essay to discuss Isaac Newton, who in turn is discarded a few lines later in favor of the volcanoes on one of Jupiter's moons.

But as soon as she leaves behind her philosopher-on-speed musings, her true gifts become apparent. In her deft hands, complex concepts — such as the union of light and matter into a single entity shortly after the Big Bang — become familiar and homey. "[T]his light and matter fluid, as physicists call it, sloshed in and out of gravity wells [until] the universe had gotten cold enough that the particles, in effect, congealed, like salad dressing left in the fridge; the light separated and escaped, like the oil on top."

Rich in such savory metaphors, Cole's prose shimmers with the brilliance of the heavens she so clearly admires. It is delightful to eavesdrop with her on the low, deep hum that is "the sound the newborn universe made when it was still wet behind the ears," otherwise known as the cosmic microwave background radiation.

In her final essays, she tackles science's political and social issues with well reasoned, engaging arguments. In "Popular Science," she eloquently defends popularizing science for the masses, reasoning that if there are spectator sports — in which fans enjoy a game without necessarily possessing the skills to play it — why not spectator science? "Experts worry that making their subject accessible to the hoi polloi strips it of its depth, tarnishes its delicate beauty," she writes.

Although marked by the occasional smudge, Cole's writing suffers from no such fault. Her writing burnishes the science she touches until it glows. — **JESSA FORTE NETTING** *is a science writer in Los Angeles.*

David Levy's Guide to Observing and Discovering Comets

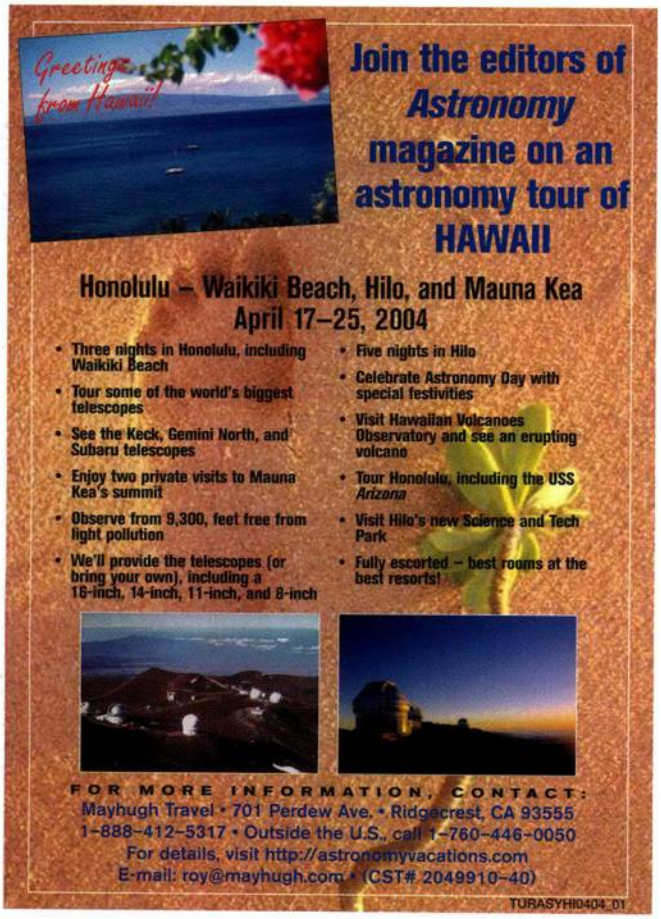
David H. Levy, 177 pages, Cambridge University Press, New York, 2003; ISBN 0–5215–2051–7; softcover, $17.

David Levy mixes prose, poetry, history, and science with his own experiences over nearly forty years of observing comets in this book, his sixth on the subject.

Levy has discovered eight comets visually from his backyard in Arizona and another thirteen photographically with Eugene and Carolyn Shoemaker using Palomar Observatory's 18-inch Schmidt camera (think Comet P/Shoemaker-Levy 9). He includes stories of these discoveries, as well as an account of how he became interested in comets, how he hunts for and observes them (using everything from his unaided eyes to a 61-inch telescope), and how and why he photographs and draws comets. This is, in a sense, an autobiography of David Levy's life with comets.

The book also covers the science and superstition associated with comets through the ages, a selected history of comet hunting, and a balanced discussion of the future of visual comet hunting. The book is well illustrated with comet pictures, many of which Levy took. Some drawings are rough but illuminating. Levy also lists 220 objects that have caused him to "stop, look, and wonder" during his more than 2,758 hours of comet hunting.

Levy set out to write about comets from his own perspective, which he has done superbly. Readers who want a primer on comet hunting, photography, or observing using more modest equipment than Levy has access to may feel a bit overwhelmed by Levy's accomplishments. Others will be motivated to explore the subject further. — **DON MACHHOLZ** *has found nine comets during 6,900 hours of visual searching and is the author of* The Observing Guide to the Messier Marathon. ■



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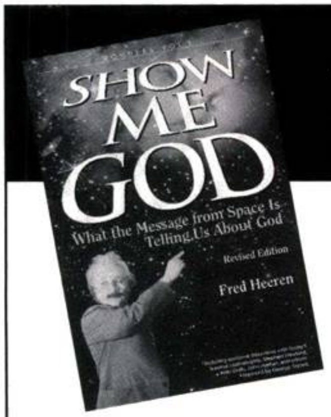

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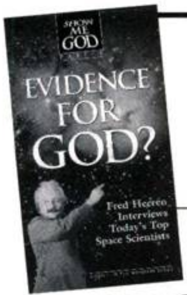

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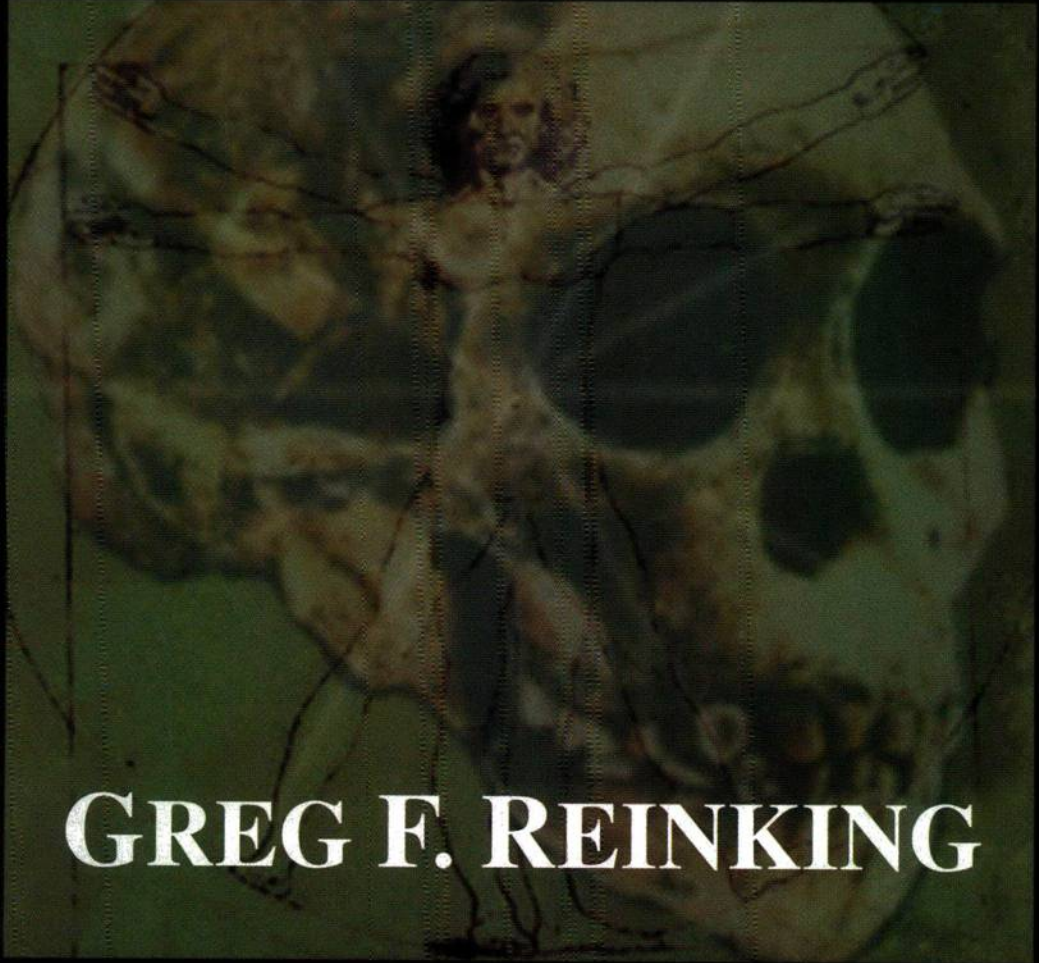

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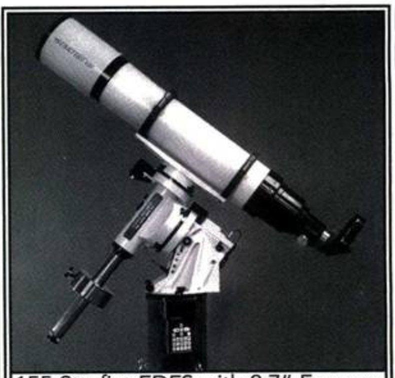

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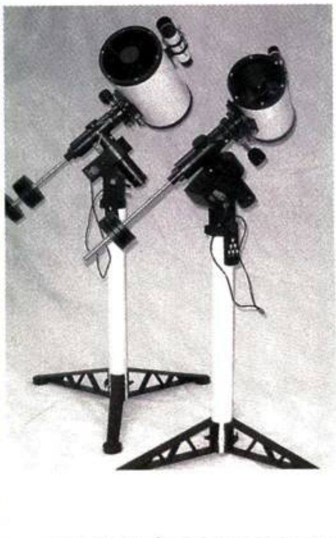

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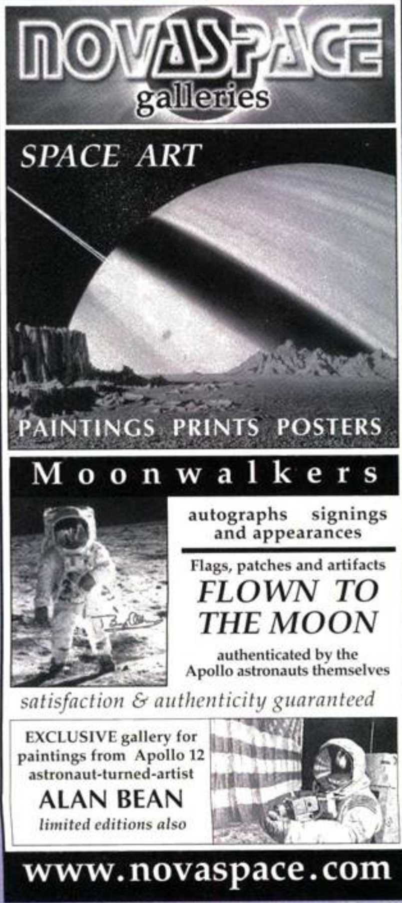

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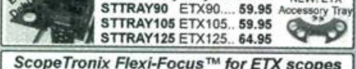

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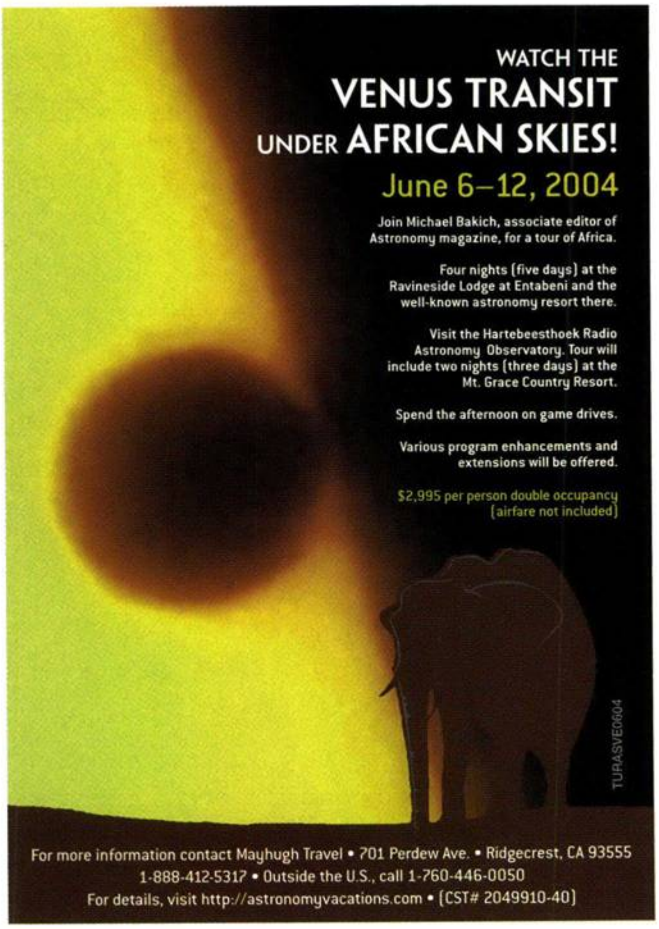

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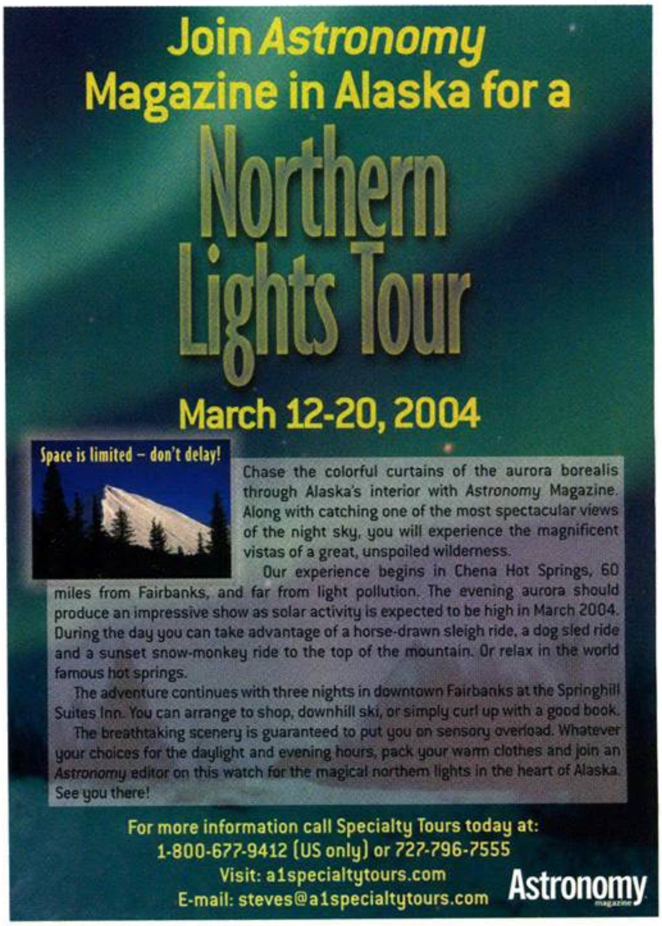

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March 12-20, 2004

Space is limited – don't delay!

Chase the colorful curtains of the aurora borealis through Alaska's interior with *Astronomy* Magazine. Along with catching one of the most spectacular views of the night sky, you will experience the magnificent vistas of a great, unspoiled wilderness.

Our experience begins in Chena Hot Springs, 60 miles from Fairbanks, and far from light pollution. The evening aurora should produce an impressive show as solar activity is expected to be high in March 2004. During the day you can take advantage of a horse-drawn sleigh ride, a dog sled ride and a sunset snow-monkey ride to the top of the mountain. Or relax in the world famous hot springs.

The adventure continues with three nights in downtown Fairbanks at the Springhill Suites Inn. You can arrange to shop, downhill ski, or simply curl up with a good book.

The breathtaking scenery is guaranteed to put you on sensory overload. Whatever your choices for the daylight and evening hours, pack your warm clothes and join an *Astronomy* editor on this watch for the magical northern lights in the heart of Alaska. See you there!

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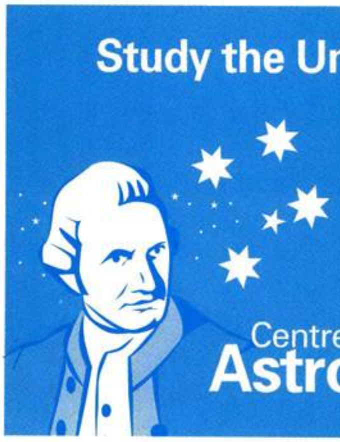

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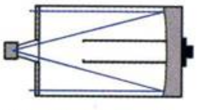
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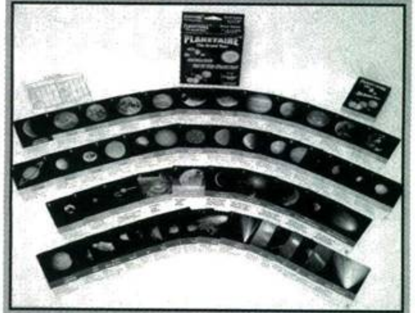

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03.12.04–03.20.04

Astronomy and Specialty Tours invite you to Alaska's interior for the 2004 Northern Lights Tour. This is your chance to join other aurorae fanatics to watch the brilliant curtains shine. The journey begins with two days in Fairbanks at the world-famous Ice Festival, a group banquet, and a lecture from noted aurora expert Neil Brown.

ALASKA'S WILDERNESS draws thousands of tourists from around the world to gaze at the colorful, glowing curtains of the Northern Lights. MARVIN NAUMAN

The trip continues with four nights in Chena Hot Springs, about an hour outside Fairbanks, where light pollution is not a factor. During the day, participate in wintertime activities, including cross-country skiing, dogsledding, sleigh rides, and snowmobiling, and take a dip in the hot springs. After the Sun sets, the real show begins. With expectations of high solar activity, the nightly aurora show should be amazing.

Chena will be followed by three more days in Fairbanks, where travelers will be able to shop, ski, enjoy the local flavor, and observe more aurorae at night.

Astronomy senior editor Rich Talcott will accompany the group, lead aurora viewing, answer questions, and point out other gems of the night sky.

For more information, call Specialty Tours at 800.677.9412 (U.S. only) or 727.796.7555; fax, 727.797.1477; e-mail, steves@a1specialtytours.com; web site, www.a1specialtytours.com.

11.29.03–12.31.03

'Tis the Season

Dreyfus Planetarium, Newark Museum, Newark, New Jersey. The annual holiday tradition continues with this 40-minute program. Besides showcasing targets of the winter sky, the planetarium will relate these celestial objects to various cultural customs. For more information, visit www.newarkmuseum.org/planetarium.

12.02.03–12.04.03

Tools and Technologies for Future Planetary Exploration

European Space Research and Technology Center, Noordwijk, Netherlands. This international symposium provides a forum for scientists and engineers to discuss the next twenty years of planetary research. The discussions will address the tools and techniques required to achieve future goals. For more information, visit astro.estec.esa.nl/Resources/conferences/Eslab37.

12.05.03

Understanding the Most Distant Galaxies

Priory Street Centre, York, England. The York Astronomical Society welcomes University of Sheffield professor of astrophysics Clive Tadhunter, who will lecture on remote galaxies. For more information, visit www.yorkastro.freeserve.co.uk/meets.html.

12.05.03

Far Out Friday

Adler Planetarium, Chicago. On the first Friday of every month, the Adler hosts an evening of astronomy-related fun, including observing, lectures, interactive displays, special demonstrations, and Doane Observatory tours. For more information, call 312.922.STAR; web site, www.adlerplanetarium.org.

12.08.03–12.12.03

American Geophysical Union Fall Meeting

Moscone Center, San Francisco. This meeting provides an occasion for researchers, teachers, students, and consultants to discuss the latest issues affecting Earth, the planets, and their environments in space. Lectures will cover all areas of geophysical science. For more information, call 800.966.2481, ext. 333; e-mail, meetinginfo@agu.org; web site, www.agu.org.

01.02.04–01.04.04

Planetfest '04

Pasadena Convention Center, Pasadena, California. The Planetary Society will celebrate space exploration with activities ranging from watching a live feed from NASA's mission control to meeting astronauts and space scientists. While organizers anticipate 10,000 people will attend in person, millions of others around the world will join in via web cast. For more information, visit www.planetary.org/planetfest04.

01.04.04–01.08.04

American Astronomical Society Meeting

Hyatt Regency, Atlanta. At the 1913 American Astronomical Society (AAS) meeting in Atlanta, Henry Norris Russell delivered a lecture that helped lead to the widespread use of the Hertzprung-Russell diagram to interpret the characteristics of stellar clusters. Nearly ninety years later, the AAS gathers again in Atlanta with Russell's momentous talk in mind. This 203rd meeting of the AAS will feature lectures, discussions, and special events. For more information, visit www.aas.org.

02.12.04–02.16.04

American Association for the Advancement of Science Annual Meeting

Washington State Convention and Trade Center and the Sheraton Seattle Hotel and Towers, Seattle. The theme of this year's annual gathering is "Science at the Leading Edge." Besides astronomy, the AAAS meeting will cover all other disciplines of science. For more information, visit www.aaas.org/meetings.

02.12.04–02.16.04

Workshop on Europa's Icy Shell: Past, Present, and Future

Center for Advanced Space Studies, near NASA's Johnson Space Center, Houston. This Lunar and Planetary Institute meeting will provide an opportunity for planetary scientists and astronomers to discuss the current understanding of Europa's icy shell, its physical state and evolution, and its interaction with the putative subsurface ocean. For more information, visit www.lpi.usra.edu/meetings/europa2004. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

Learn more about this issue's topics:

HUBBLE'S DAZZLING DECADE

BOOKS — Many excellent books about the Hubble Space Telescope have been published, nearly all of them lavishly illustrated with images from the Wide Field and Planetary Camera 2. Among the best are *Hubble: The Mirror on the Universe* by Robin Kerrod (Firefly Books, Toronto, 2003) and *Hubble Vision: Further Adventures with the Hubble Space Telescope*, 2nd edition, by Carolyn Collins Petersen and John C. Brandt (Cambridge University Press, New York, 1998).
WEB — Visit the telescope's official web page at hubblesite.org, and you'll find a gallery of great Hubble images (as well as wallpaper for your computer screen), clear explanations of the science behind the telescope's discoveries, and much more.

GHOSTBUSTING THE UNIVERSE

BOOKS — In the world of particle physics, it's easy to get lost. An excellent, illustrated guidebook is *The Particle Odyssey* by Frank Close, et al. (Oxford University Press, New York, 2002). To explore how neutrinos fit into astronomers' evolving picture of the cosmos, take a look at Tim Ferris's *The Whole Shebang* (Simon & Schuster, New York, 1997). For a good overview of the latest developments in cosmology, see Charles Seife's *Alpha & Omega* (Viking Press, New York, 2003).
WEB — Neutrino experiments are legion, and they all have web sites. Start your exploring at www.sno.phy.queensu.ca/.

THE BLACK CLOUD

BOOKS — Ken Croswell's *Magnificent Universe* (Simon & Schuster, New York, 1999) shows beautiful color images of numerous nebulae. To find out more about the man who helped connect these small, icy clouds to star birth, check out *The Man Who Sold the Milky Way: A Biography of Bart Bok* by David Levy (University of Arizona Press, Tucson, Arizona, 1993). Readers aged 9 to 12 can find a clear primer on stellar birth in astronomer Ray Jayawardhana's book, *Star Factories: The Birth of Stars and Planets* (Steck-Vaughn, Austin, Texas, 2000).

TYCHO BRAHE

BOOKS — Kitty Ferguson's recent book *Tycho & Kepler: The Unlikely Partnership That Forever Changed Our Understanding of the Heavens* (Walker & Co., New York, 2002) brings the motivations and personalities of Tycho and his protégé to life. Information on Tycho's instruments and models for the solar system can be found in Victor Thoren's *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge University Press, New York, 1990).
WEB — Join Kitty Ferguson on a tour of Tycho and Kepler's Prague at www.tychoandkepler.com/walking_tour.php. Or take a virtual tour of "The Noble Dane: Images of Tycho Brahe," an exhibit at the Museum of the History of Science, Oxford, at www.mhs.ox.ac.uk/tycho/index.htm.

OCTANS, VOLANS, AND CHAMAELEON

BOOKS — Beginning and veteran observers alike will benefit from the third edition of *The Cambridge Star Atlas* by Wil Tirion (Cambridge University Press, Cambridge, England, 2001). This easy-to-use guide features monthly sky maps for both hemispheres and star charts providing a closer look at each section of the sky.

If the deep-sky wonders of the Southern Hemisphere intrigue you, consider adding *Exploring the Southern Sky: A Pictorial Atlas from the European Southern Observatory* by Sven Laustsen, et al. (Springer-Verlag, Berlin, 1987) to your library. More of a coffee-table book than an observing guide, its photos and descriptions will introduce those unfamiliar with the Southern sky to the sights.

THE LURE OF METEORITES

BOOKS — O. Richard Norton's books, *Rocks from Space: Meteorites and Meteorite Hunters*, 2nd edition (Mountain Press, Missoula, Montana, 1998) and *The Cambridge Encyclopedia of Meteorites* (Cambridge University Press, New York, 2002), cover meteoritics and the different types of meteorites, respectively. *Thunderstones and Shooting Stars: The Meaning of Meteorites* by Robert T. Dodd (Harvard University Press, Cambridge, Massachusetts, 1988) is an easy-to-read survey.
WEB — One of the most enduring meteorite dealers is Robert Haag of Tucson, Arizona. Find him on the Internet at www.meteoriteman.com. Searching for more information before you buy? Look at and subscribe to *Meteorite* magazine, a quarterly publication, on-line at www.meteor.co.nz.

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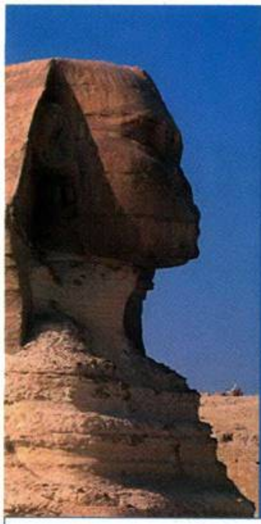
A quality reference library will contain more than books, though. For example, many *Astronomy* readers archive each issue. You may want to have each year's worth of magazines bound — professionally or with a binder you purchase yourself. Wire binders for *Astronomy* may be ordered at store.yahoo.net/kalmbachcatalog/14007.html.

IMAGING WITH WEBCAMS

BOOKS — *Guide to Webcams* by John Breeden and Jason Byrne (Delmar Learning, Albany, New York, 2000) provides an introduction to the topic.
WEB — The QuickCam and Unconventional Imaging Astronomy Group (QCUIAG) maintains an on-line listserv — members send e-mails to one location and the e-mails are distributed to the entire group — at groups.yahoo.com/group/QCUIAG. With more than 4,000 members, if you have questions about webcams and astrophotography, this listserv is the place to find answers. ◼



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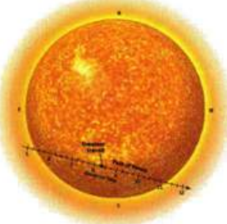

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Deep Space Mysteries 2004 Calendar

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2004 Calendar
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Reader gallery

Readers share their images . . .

Mars, Mars, and more Mars.

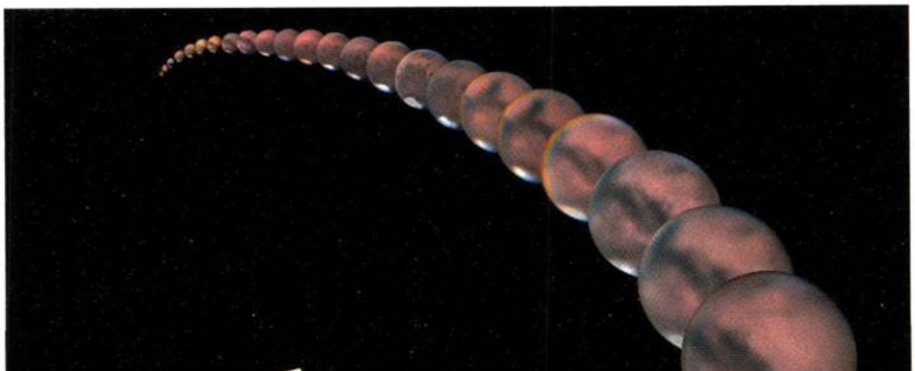
THE RED PLANET

Mars mania!

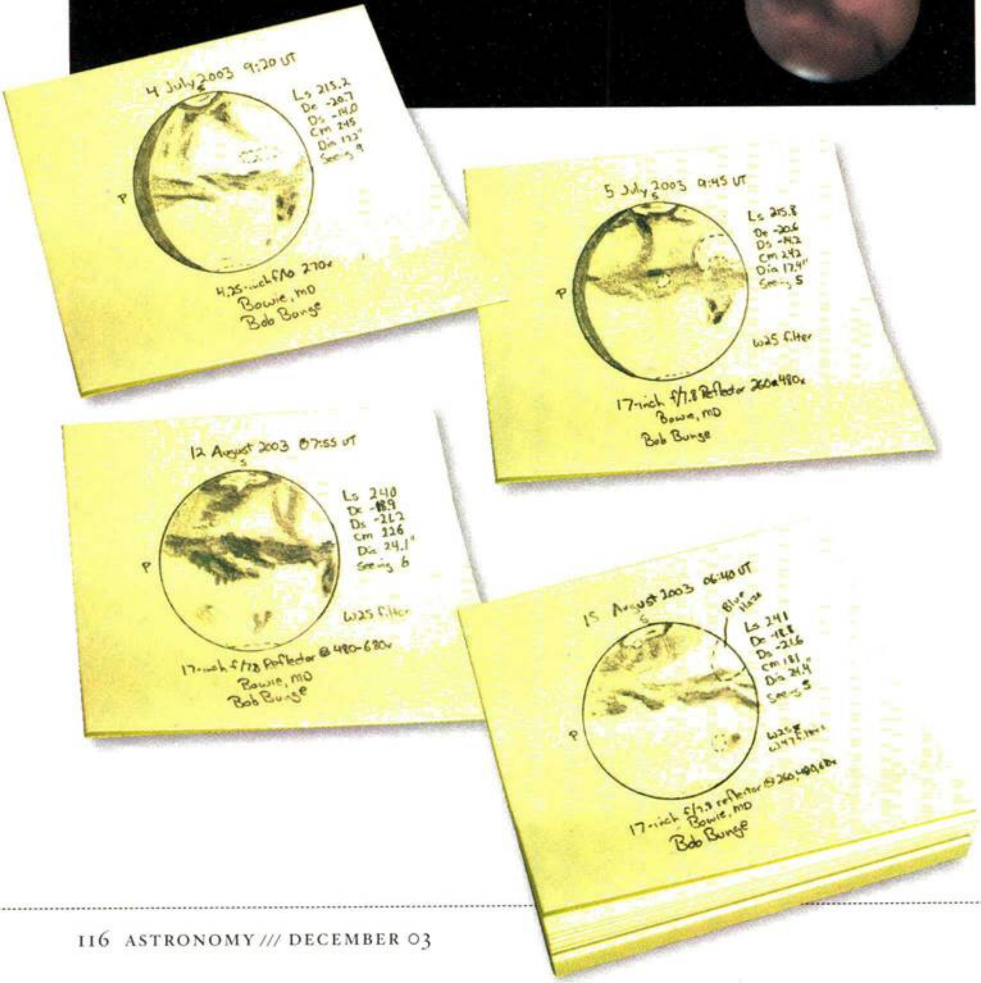
The 2003 apparition of Mars was anticipated by amateur astronomers for years — and it did not disappoint. As August ended, Mars's apparent diameter was an incredible 25.1", the largest anyone alive will ever see. The planet's apparent visual magnitude on the 27th was –2.9. In addition, the much-feared global dust storms did not materialize, leaving the planet's features easy to observe.

Astronomical imagers took advantage of every opportunity. They documented the face of Mars on paper, film, and chip on each clear night.

In honor of the fabulous show put on by the Red Planet, this special "Reader gallery" presents 175 images as a lasting reminder of an historic astronomical event.

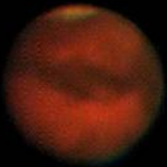


Top, **MARS GROWS OVER MONTHS** (8-inch Newtonian reflector at f/5, Philips Vesta webcam using eyepiece projection with a 10mm Plössl eyepiece; each image is the best ten to twenty images compiled from a 60-second AVI file of approximately 300 images) /// **BERT CANDUSIO**

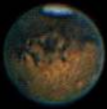

4 July 2003 9:20 UT
S
Ls 215.2
De -20.7
Ds -14.0
Cm 245
Dia 17.2"
Seeing 9
P
4.25-inch f/10 270x
Bowie, MD
Bob Bunge
5 July 2003 9:45 UT
S
Ls 215.8
De -20.6
Ds -14.2
Cm 242
Dia 17.4"
Seeing 5
P
W25 filter
17-inch f/7.8 Reflector 260x480x
Bowie, MD
Bob Bunge
12 August 2003 07:55 UT
S
Ls 240
De -18.9
Ds -21.2
Cm 226
Dia 24.1"
Seeing 6
P
W25 filter
17-inch f/7.8 Reflector @ 480-680x
Bowie, MD
Bob Bunge
15 August 2003 06:40 UT
Blue Haze
S
Ls 241
De -18.8
Ds -21.6
Cm 181
Dia 24.9"
Seeing 5
P
W25 & W47 filters
17-inch f/7.8 reflector @ 260,480,680x
Bowie, MD
Bob Bunge

Bottom, **SKETCHES OF THE RED PLANET** (earliest sketch made through a 4¼-inch Newtonian reflector at f/10, magnification of 270x; later sketches made through a 17-inch Newtonian reflector at f/7.8, magnification ranging from 260x to 680x; all sketches made July 4 to August 15, 2003, from Bowie, Maryland) /// **BOB BUNGE**

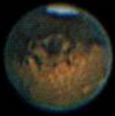
Send your photos to: ASTRONOMY Reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com.
Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.



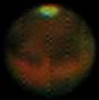
8-inch Maksutov at f/15.5
Philips ToUcam Pro webcam
August 16
ALBERTO LEVY



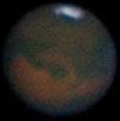
Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 23
P. CLAY SHERROD



Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 24
P. CLAY SHERROD

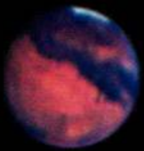


Meade 10-inch SCT at f/50
Philips ToUcam Pro
August 27
ADAM STUART



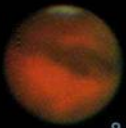
7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 23
PAOLO R. LAZZAROTTI

8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 18
ALBERTO LEVY

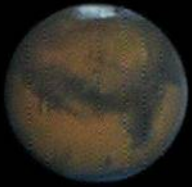


Meade 16-inch SCT at f/25
Philips ToUcam Pro
August 18
JACK NEWTON

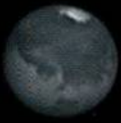
8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 13
ALBERTO LEVY



8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 17
ALBERTO LEVY



Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
August 22
TAN WEI LEONG

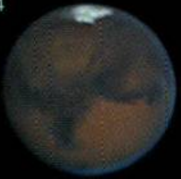


7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 23
PAOLO R. LAZZAROTTI

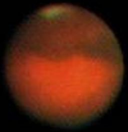
8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 10
ALBERTO LEVY

Meade 10-inch SCT
Starlight Xpress HX916 CCD camera
August 19
EUGENE FAULKNER

8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 9
ALBERTO LEVY

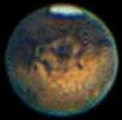


Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
August 20
TAN WEI LEONG

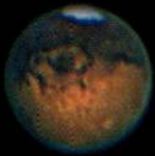


8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 18
ALBERTO LEVY

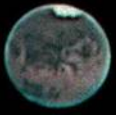
Meade 10-inch SCT at f/20
Philips Vesta Pro webcam
August 26
TIM JENSEN



Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 25
P. CLAY SHERROD

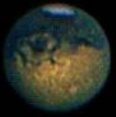


Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 25
P. CLAY SHERROD

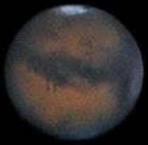


USNO 12-inch refractor
Philips ToUcam Pro
August 26
GEOFF CHESTER

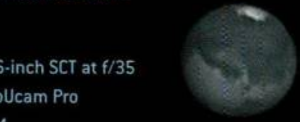
Takahashi 4-inch FS102 at f/8
Philips ToUcam Pro
August 21
CHRIS COOK AND JOHN BOUDREAU



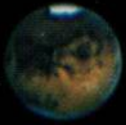
Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 23
P. CLAY SHERROD



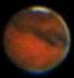
Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
August 25
TAN WEI LEONG



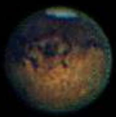
7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 21
PAOLO R. LAZZAROTTI



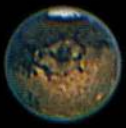
Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 27
P. CLAY SHERROD



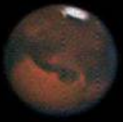
8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 17
ALBERTO LEVY



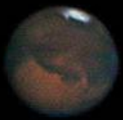
Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 24
P. CLAY SHERROD



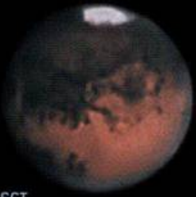
Meade 16-inch SCT at f/35
Philips ToUcam Pro
August 23
P. CLAY SHERROD



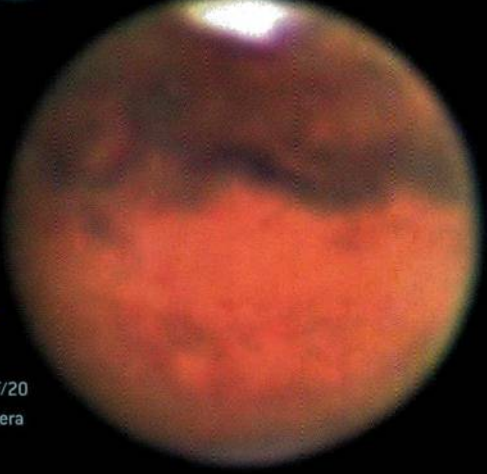
7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 27
PAOLO R. LAZZAROTTI



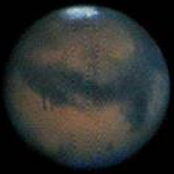
7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 24
PAOLO R. LAZZAROTTI



Meade 10-inch SCT
Philips ToUcam Pro
August 22
DAMIAN PEACH



Meade 14-inch SCT at f/20
Pictor 416xte CCD camera
August 19
JOE PETRICK

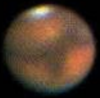


Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
August 20
TAN WEI LEONG

Meade 10-inch SCT at f/50
Philips ToUcam Pro
August 18
ADAM STUART

Meade 10-inch SCT at f/50
Philips ToUcam Pro
August 18
ADAM STUART

Celestron 11-inch SCT
Nikon Coolpix 4600 webcam
August 3
BENNIE NEGY, JR.

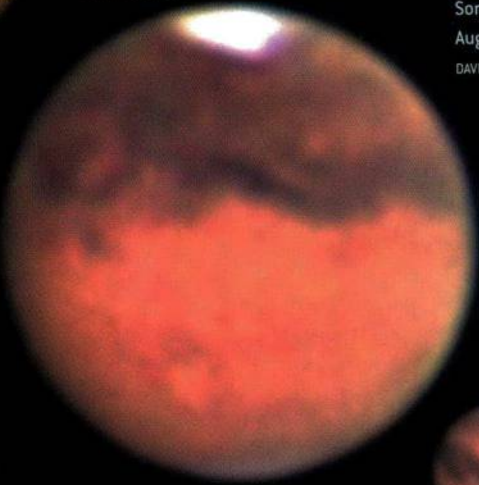


Meade 10-inch SCT
Sony video camera on tripod
August 3
DAVID JOHNSON

18-inch Newtonian reflector
Philips ToUcam Pro
August 1
GERARD DOYLE

Ritchey-Chrétien 12.5-inch reflector
SBIG ST8XE CCD camera
June 18
RICHARD JACOBS

8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 17
ALBERTO LEVY



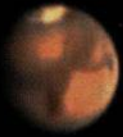
Meade 14-inch SCT at f/20
Pictor 416xte CCD camera
August 19
JOE PETRICK

8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 20
BERT CANDUSIO

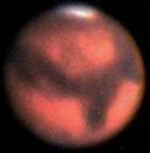
8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 6
BERT CANDUSIO

8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 12
BERT CANDUSIO

6-inch Newtonian reflector at f/8
Philips ToUcam Pro
July 23
RICHARD JAWORSKI

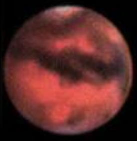


8-inch Newtonian reflector at f/12.5
Philips ToUcam Pro
July 26
JESÚS ALEU DELGADO DE MENDOZA



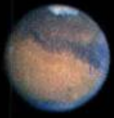
8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 14
BERT CANDUSIO

9-inch homemade reflector at f/40
Philips ToUcam Pro
August 12
ATTILA SCHNÉ

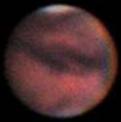


8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 19
BERT CANDUSIO

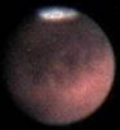
Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
July 8
TAN WEI LEONG



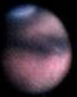
6-inch Sky-Watcher refractor
Sony TRV 740E video camera
August 17
RALF VANDEBERGH



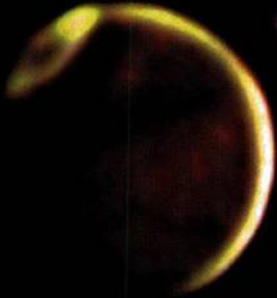
8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 20
BERT CANDUSIO



8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 2
BERT CANDUSIO

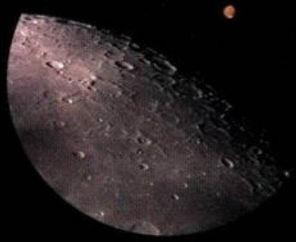


8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 21
BERT CANDUSIO



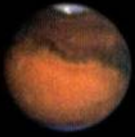
6-inch Sky-Watcher refractor
Sony TRV 740E video camera
June 29
RALF VANDEBERGH

Ritchey-Chrétien 12.5-inch reflector
SBIG ST8XE CCD camera
June 21
RICHARD JACOBS



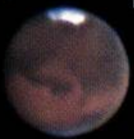
Meade 8-inch SCT
Nikon CP995 digital camera
July 17
RON WAYMAN

Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
June 8
TAN WEI LEONG

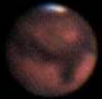


8-inch Newtonian
Philips ToUcam Pro
August 18
TOM WILLIAMSON

8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 29
BERT CANDUSIO

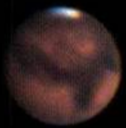


8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 15
BERT CANDUSIO

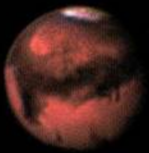


8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 15
BERT CANDUSIO

Intes MK-69 reflector
SBIG STV CCD camera
August 15
WARREN A. KELLER

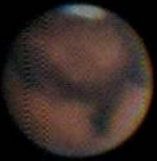


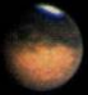
8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 15
BERT CANDUSIO

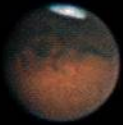


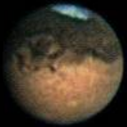
12.5-inch Newtonian reflector
Philips ToUcam Pro
August 10
ROLANDO CHAVEZ

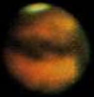
6-inch Newtonian reflector at f/8
Philips ToUcam Pro
July 23
RICHARD JAWORSKI


8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 14
BERT CANDUSIO

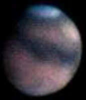

9-inch homemade reflector at f/40
Philips ToUcam Pro
August 12
ATTILA SCHNE

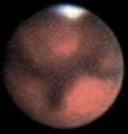

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 27
PAOLO R. LAZZAROTTI

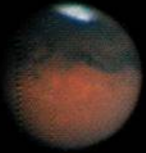

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 10
PAOLO R. LAZZAROTTI

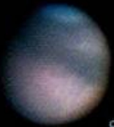

8-inch Maksutov reflector
Philips ToUcam Pro
August 13
ALBERTO LEVY

4¼-inch Newtonian reflector
Philips ToUcam Pro
August 10
ALIREZA VAFA


8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 18
BERT CANDUSIO


8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 14
BERT CANDUSIO


7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 10
PAOLO R. LAZZAROTTI


8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 17
BERT CANDUSIO

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 12
PAOLO R. LAZZAROTTI

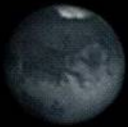
8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 24
BERT CANDUSIO

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
July 8
PAOLO R. LAZZAROTTI

Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
July 18
TAN WEI LEONG

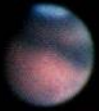
8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 10
BERT CANDUSIO

26-inch SCT at f/16
SBIG ST8 CCD camera
July 4
PAUL GARDNER


7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 19
PAOLO R. LAZZAROTTI

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC381 CCD camera
August 20
PAOLO R. LAZZAROTTI

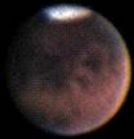
8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 21
BERT CANDUSIO

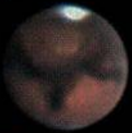

8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 23
BERT CANDUSIO

26-inch SCT at f/16
SBIG ST8 CCD camera
July 4
PAUL GARDNER

8-inch Newtonian reflector at f/5
Philips Vesta webcam
April 30
BERT CANDUSIO

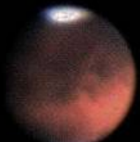
8-inch Newtonian reflector at f/5
Philips Vesta webcam
May 24
BERT CANDUSIO


8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 31
BERT CANDUSIO

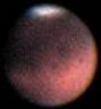

Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
June 8
TAN WEI LEONG

7-inch Maksutov-Cassegrain at f/15
Astromecchanica KC331 CCD camera
August 16
PAOLO R. LAZZAROTTI

Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
July 15
TAN WEI LEONG

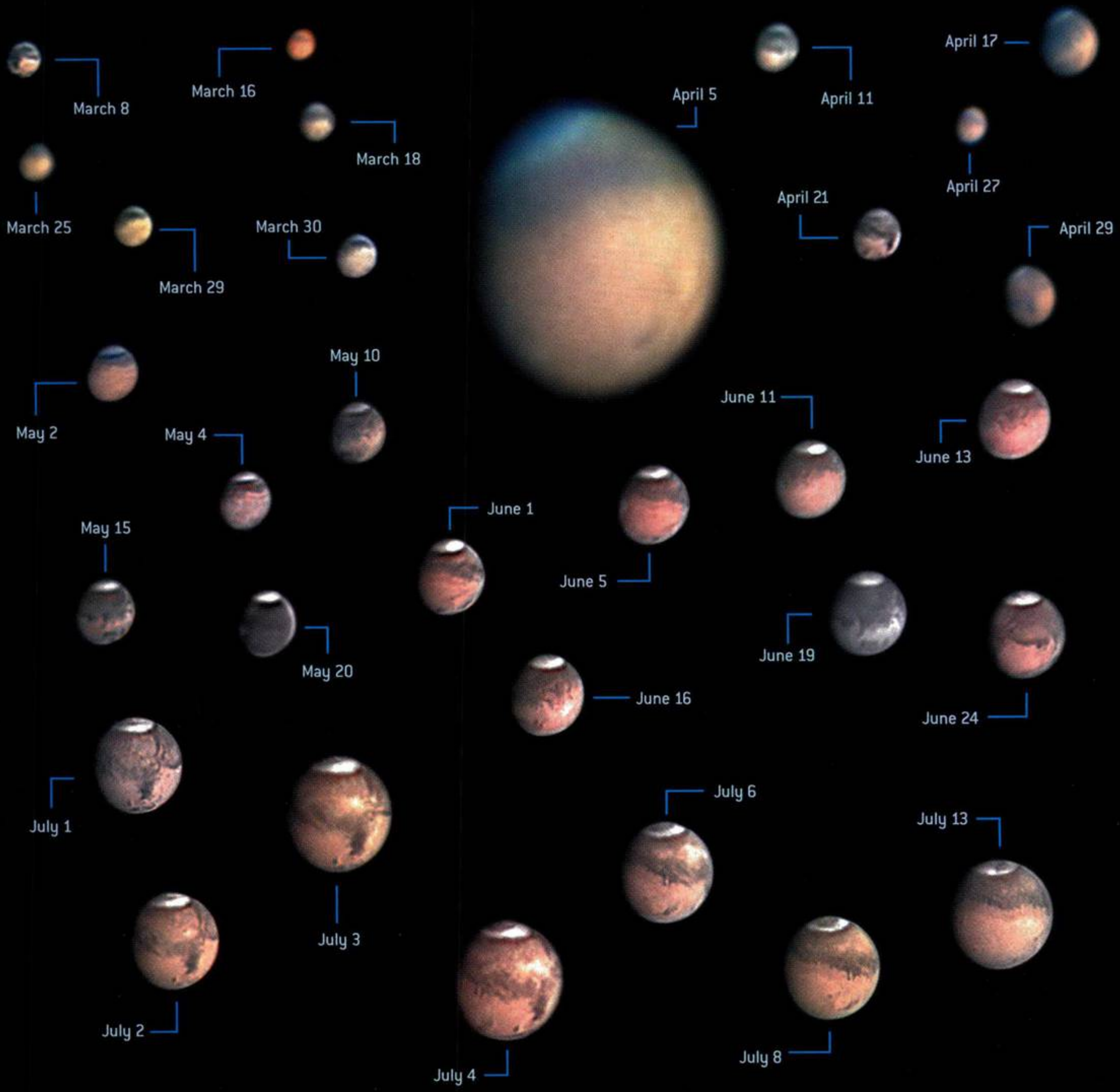

8-inch Newtonian reflector at f/5
Philips Vesta webcam
August 1
BERT CANDUSIO

Sony DSC-S75 digital camera
ISO 400 equivalent
August 14
STEVE MILLER

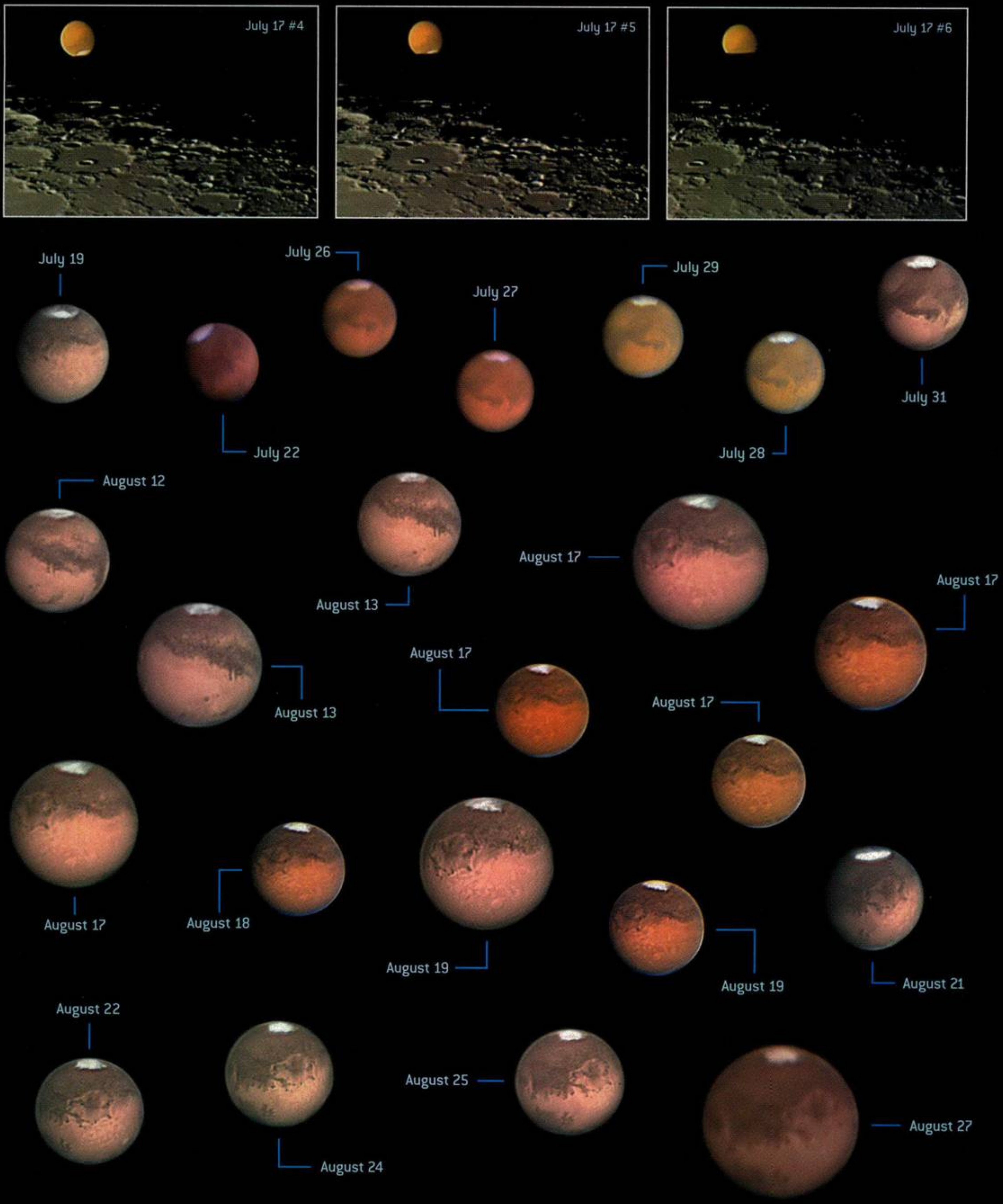

8-inch Newtonian reflector at f/5
Philips Vesta webcam
July 30
BERT CANDUSIO

6-inch Sky-Watcher refractor
Sony TRV 740E video camera
June 25
RALF VANDEBERGH

GALLERY FEATURE /// MARS IMAGES ON THESE PAGES WERE TAKEN BY


March 8
March 16
March 18
March 25
March 29
March 30
April 5
April 11
April 17
April 21
April 27
April 29
May 2
May 4
May 10
May 15
May 20
June 1
June 5
June 11
June 13
June 16
June 19
June 24
July 1
July 2
July 3
July 4
July 6
July 8
July 13

DONALD PARKER WITH A 16-INCH NEWTONIAN REFLECTOR, SBIG ST9XE CCD CAMERA, FROM CORAL GABLES, FLORIDA.



July 17 #4

July 17 #5

July 17 #6

July 19

July 26

July 27

July 29

July 31

July 22

July 28

August 12

August 13

August 17

August 17

August 13

August 17

August 17

August 17

August 18

August 19

August 19

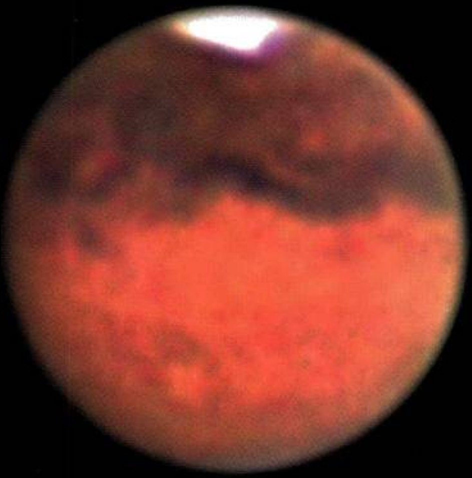
August 21

August 22

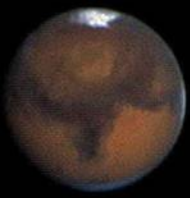
August 24

August 25

August 27



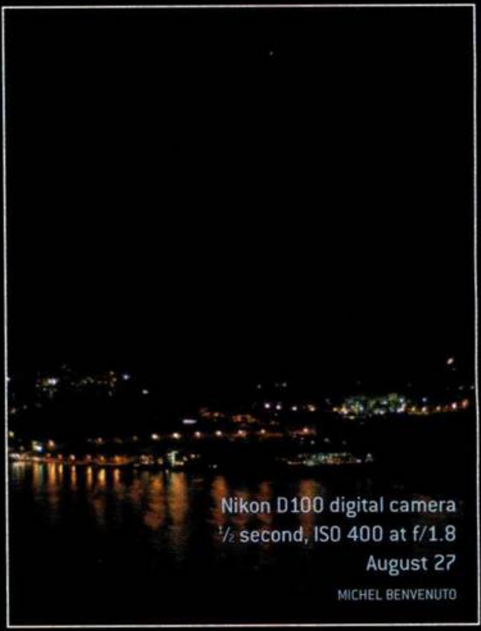
Meade 14-inch SCT at f/20
Pictor 416xte CCD camera
August 19
JOE PETRICK



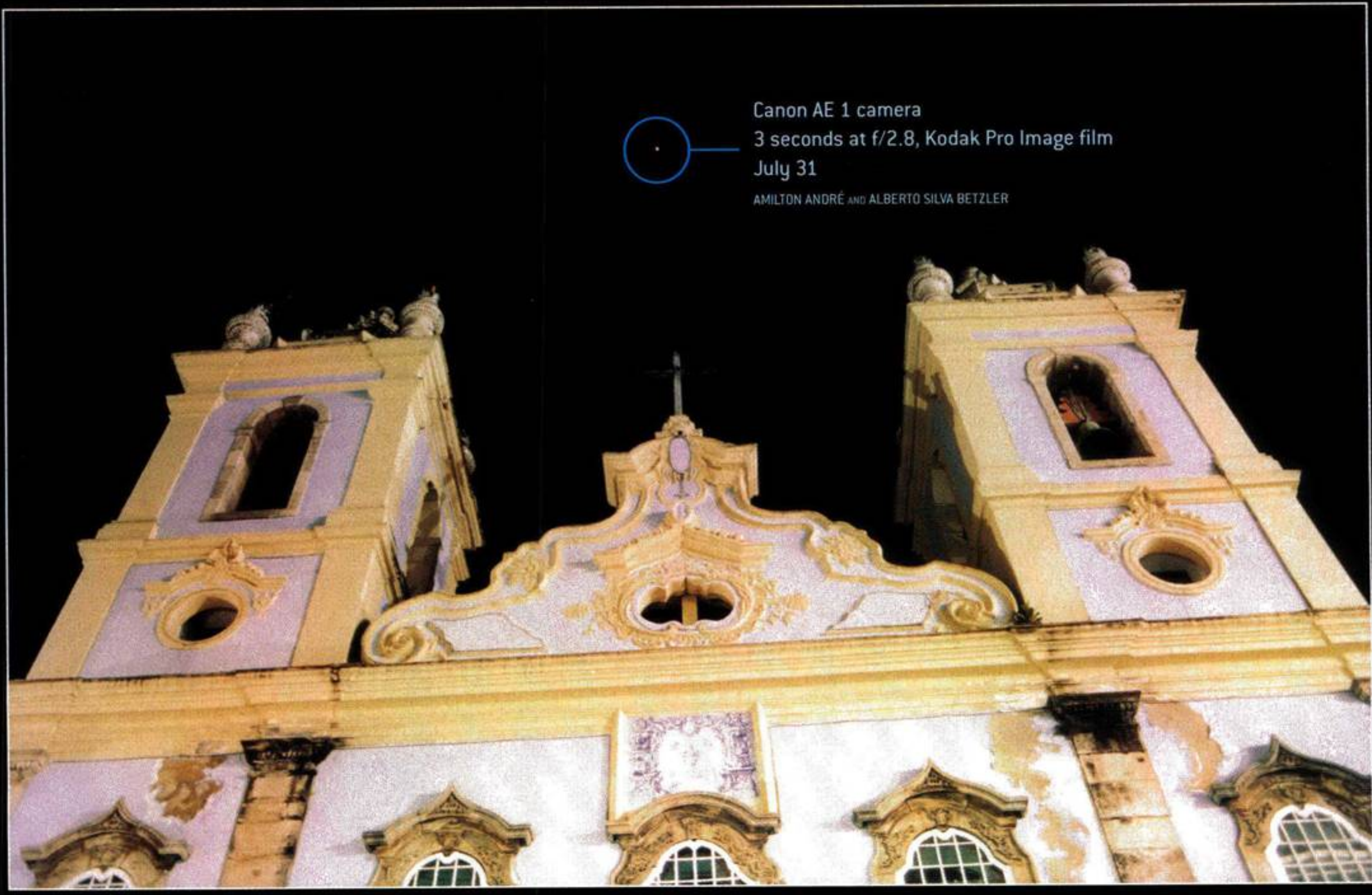
Pentax 16-inch Cassegrain at f/14
Philips PCVC 740K webcam
August 20
TAN WEI LEONG

12.5-inch Ritchey-Chrétien reflector
SBIG ST8XE CCD camera
June 21
RICHARD JACOBS

8-inch Maksutov at f/15.5
Philips ToUcam Pro
August 16
ALBERTO LEVY



Nikon D100 digital camera
½ second, ISO 400 at f/1.8
August 27
MICHEL BENVENUTO



Canon AE 1 camera
3 seconds at f/2.8, Kodak Pro Image film
July 31
AMILTON ANDRÉ AND ALBERTO SILVA BETZLER

Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Post Publication Agreement Number 40010760.

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